THE FOUNDRY

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A Successfully-Operated Two-Ton Open-Hearth

Description of a Small Furnace for Making Steel for Casting Purposes, Which Has a Record of Four and Five Heats Daily and a Long Campaign Without Relining

IN STEEL casting manufacture four distinct processes are employed, namely the crucible, the open-hearth, the converter and the electric. The pot furnace was the first introduced and is in extensive use today because of its well-known advantages for making small heats and for producing light castings. The converter, in small units, also is well-adapted to steel foundry operations, since the steel can be blown in a comparatively short period and the metal is exceedingly hot and fluid for running small sections. The electric furnace, because of its ease of manipulation, control and adaptability to small heats is a welcome newcomer in the steel foundry industry, and the fact that this process is receiving wide recognition by the installation of many electric units is indicative of its practicability. The open-hearth process, both acid and basic, in tonnage at least, leads all other steel casting methods. With few exceptions, the furnaces are of large capacity and are designed primarily for the production of large castings. Owing to the big output of

FIG. 1—TAPPING SIDE OF TWO-TON OPEN-HEARTH FURNACE

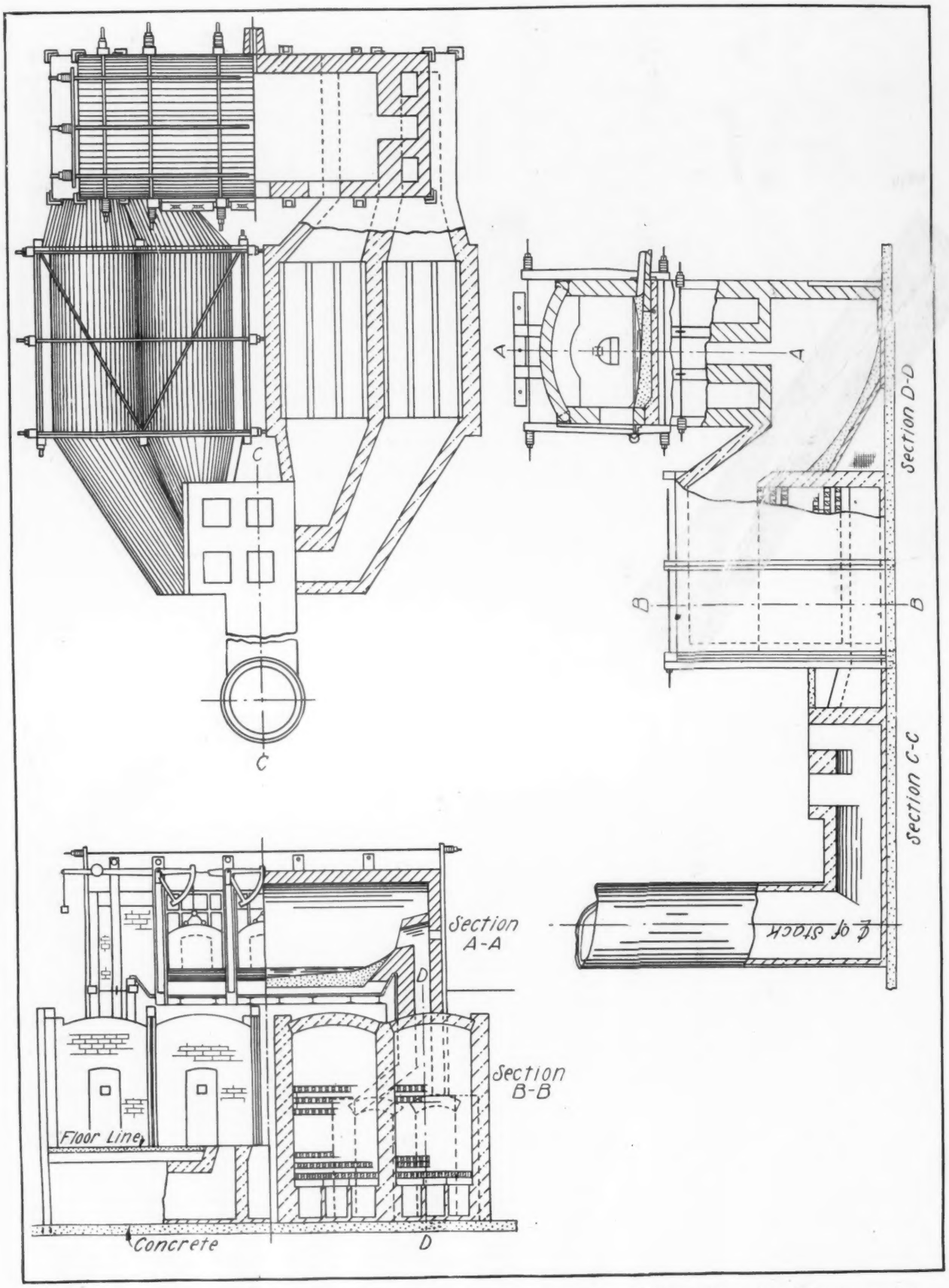


FIG. 2—TWO-TON OPEN-HEARTH FURNACE SHOWING PLAN VIEW OF REGENERATORS AND FLUES; FRONT ELEVATION AND LONGITUDINAL CROSS-SECTION AND LONGITUDINAL ELEVATION AND SECTIONAL VIEWS OF FURNACE

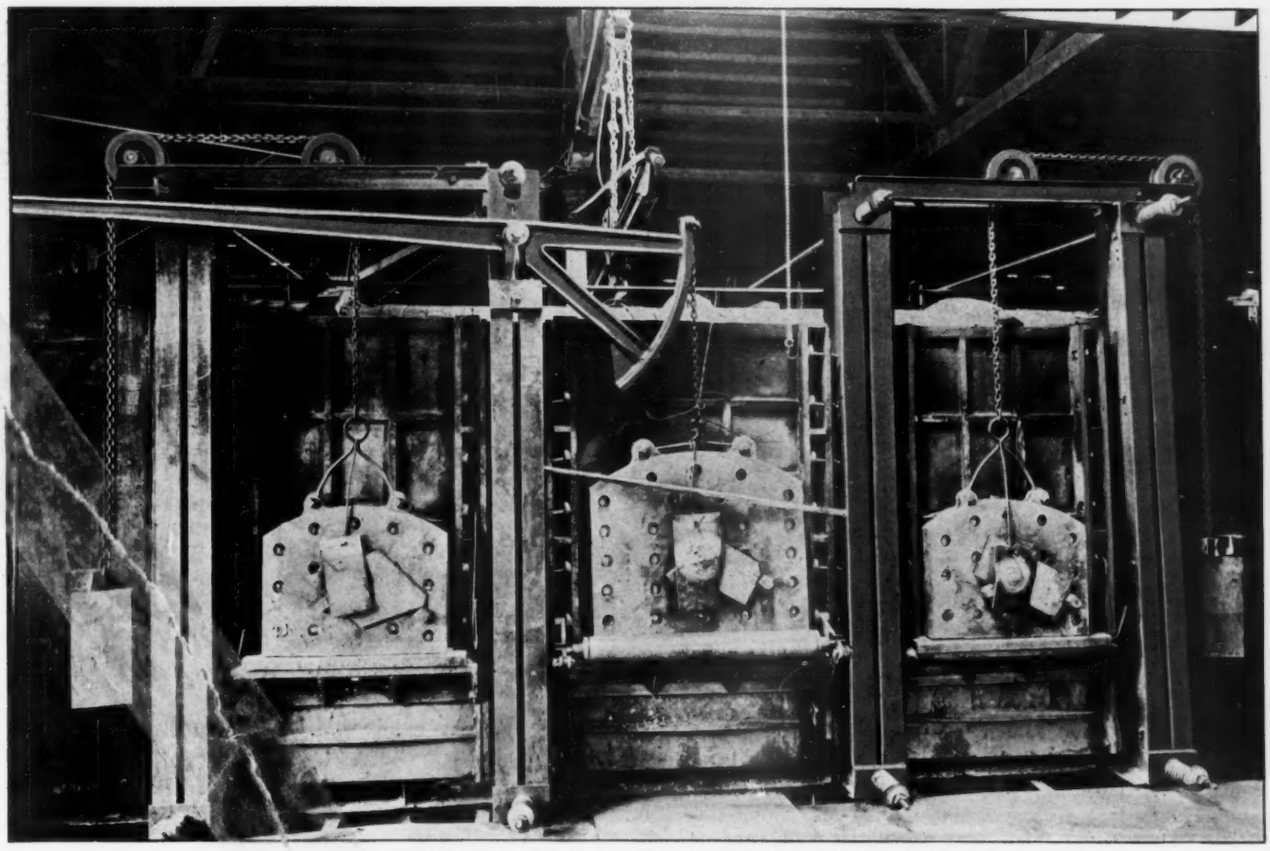


FIG. 3—CHARGING SIDE OF TWO-TON OPEN-HEARTH FURNACE

the individual units and the time required to pour the metal, success has not always followed the efforts to pour light castings, although the ease of manipulating the heats and the control of the metal throughout this steelmaking process has proved exceedingly advantageous to the steel foundryman.

With so many points in its favor, both open-hearth furnace designers and operators concluded that the small unit of a few tons capacity would prove a valuable addition to the steel-producing mediums for the foundryman and many experiments have been made with this end in view. It was argued that since the converter was reduced in size to small vessels of 1,500 pounds to three tons capacity per heat, no great difficulty would be experienced in scaling down the dimensions of the large open-hearth to meet the needs of the foundryman for small heats and hot metal for light casting work. Many furnaces were built, ranging in capacity from one to five tons, which produced steel satisfactorily in a much shorter time than was possible in large furnaces, but in most instances the life of the furnace was limited, the chief difficulty having been due to the burning-out of the lining and roof. Being compelled to reline after a few heats raised the cost of production to exorbitant figures and furthermore, the idleness due to this cause made the small furnace impracticable without a spare unit in reserve. The rapid burning-out of the lining and roof was attributed to the radiated heat from the walls and the roof which was greatly contracted in size, and caused a tremendous increase in the temperature of the furnace. While the melting and refining operations were speeded-up, nevertheless the brickwork could not withstand the heat for any considerable campaign.

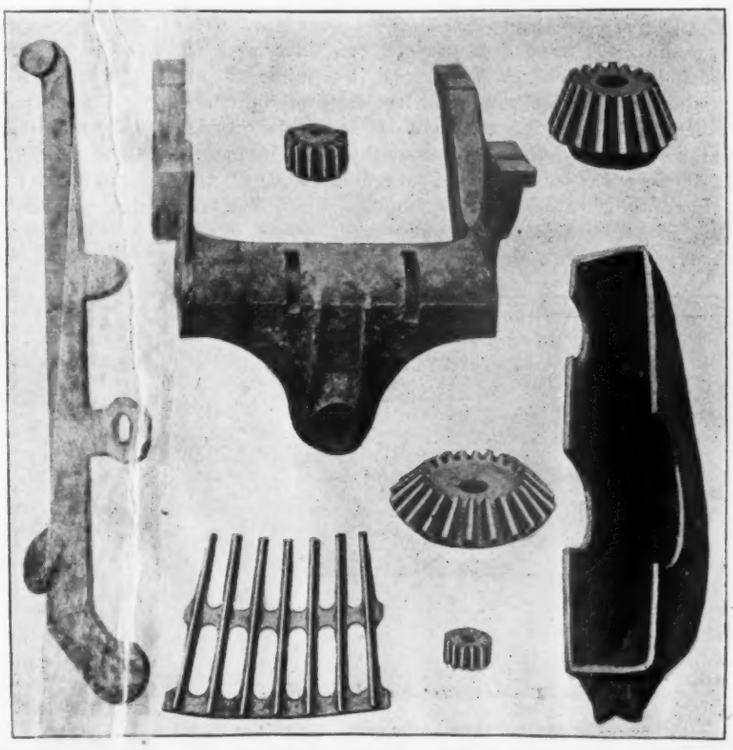


FIG. 4—LIGHT AND HEAVY CASTINGS POURED FROM STEEL MADE IN THE TWO-TON OPEN-HEARTH FURNACE

Another experiment in the design and installation of a small open-hearth furnace recently has been made at the plant of the Standard Crucible Steel Casting Co., Milwaukee, from plans prepared by David

McLain and Frank Carter, of that place. With a long record of failures before them, they concluded to build a furnace of a size entirely out of proportion to its steel-making capacity. That they have succeeded is indicated by the long run already attained and neither the lining nor roof show any need of early repair or replacement. The first heat was made on March 2, this year, and up to April 6, when the data for this article were obtained, 105 heats had been tapped. Since that time an average of four to five heats have been made daily and miscellaneous castings are successfully poured weighing from a few ounces to 500 and 600 pounds. Furthermore, the metal is being produced at an average cost of $29 to $30 a ton, which is a comparatively low figure considering the present cost of pig iron, scrap, ferro-manganese and ferro-silicon, and measures-up closely to that of furnaces having a much larger output and is far below the cost of crucible steel.

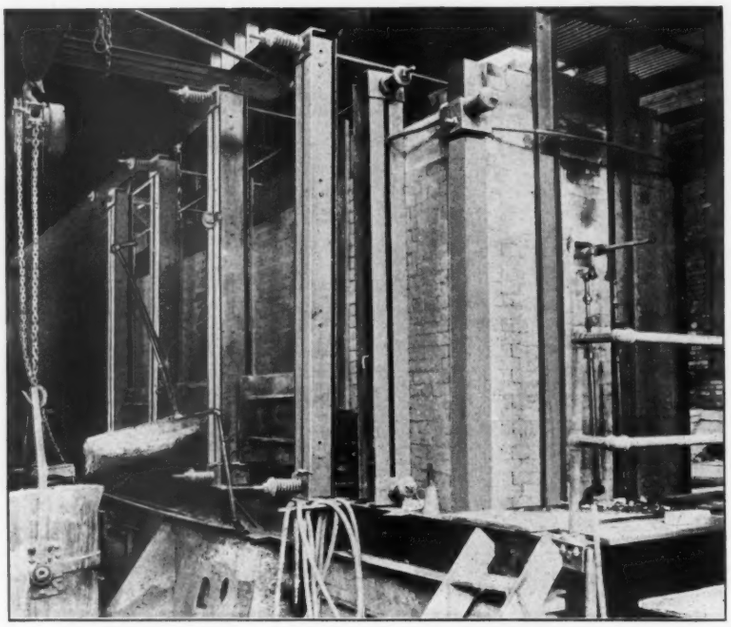


FIG. 5—END VIEW OF THE FURNACE SHOWING ONE OF THE PORTS

Plan, elevation and sectional views of the furnace, which is of the acid, stationary type and of two tons capacity, are shown in Fig. 2. The regenerators are unusually large and are ample for a furnace of a much larger size. The concrete pit in which the regenerative chambers have been built is 25 feet x 39 feet, 8 inches, and the furnace is 21 feet wide and 35 feet 4 inches long. The stack is lined to a diameter of 42 inches and is 85 feet high. The hearth is 4 feet by 8 feet 6 inches and the bath of metal is very shallow, being only 7 inches deep. The roof is arched at a height of 5 feet above the bath. In this furnace, it will be noted that the area of the bed per ton of capacity is 17 square feet, whereas in larger furnaces this area is reduced approximately one-half per ton of output. In some representative open-hearth furnaces operated in this country, the area of the bed per ton of capacity follows: Fifty-ton furnaces, 8.4 to 9 square feet; 60 tons, 7.87 to 8.13 square feet, and 75 tons, 8.53 to 9.6 square feet. This large area per ton combined with the shallow bath make it possible to produce steel from the time of the charging of the cold stock to the tapping of the metal into the ladle in periods varying from one hour and 40 minutes to two hours. Four and five heats are readily made per day with an oil consumption of 50 to 55 gallons per ton of steel and only 20 gallons of oil per hour are required to keep the furnace hot when not melting.

The manipulation of the furnace is similar to that of open-hearths of larger capacity, although the cold stock is melted much more rapidly and the time of the refining operation is greatly reduced. In practically all heats the cold stock, consisting of pig iron and scrap is reduced in 45 minutes and a carbon test is made, by fracture only, about 10 minutes before the metal is tapped. Due to the speed with which the furnace can be emptied, ferro-alloys for alloy steels can be added in the furnace in place of in the ladle. Ferro-titanium, however, is sprinkled preferably on the stream of metal as it flows into the ladle. The oil burners enter either end of the furnace and the air and gas are reversed every 20 minutes. The burner tip consists of a wrought steel pipe, flattened at the outlet end, which can readily be replaced when burned off.

The tapping side of the furnace is shown in Fig. 1 and it will be noted that the structural supports and tie rods are of substantial construction. The arched, silica brick roof was laid dry and no repairs have been made up to the present time. Fig. 3 is a view of the charging side and Fig. 5 is an end view of the furnace showing one of the ports with the burner in operating position.

For the four heats made on April

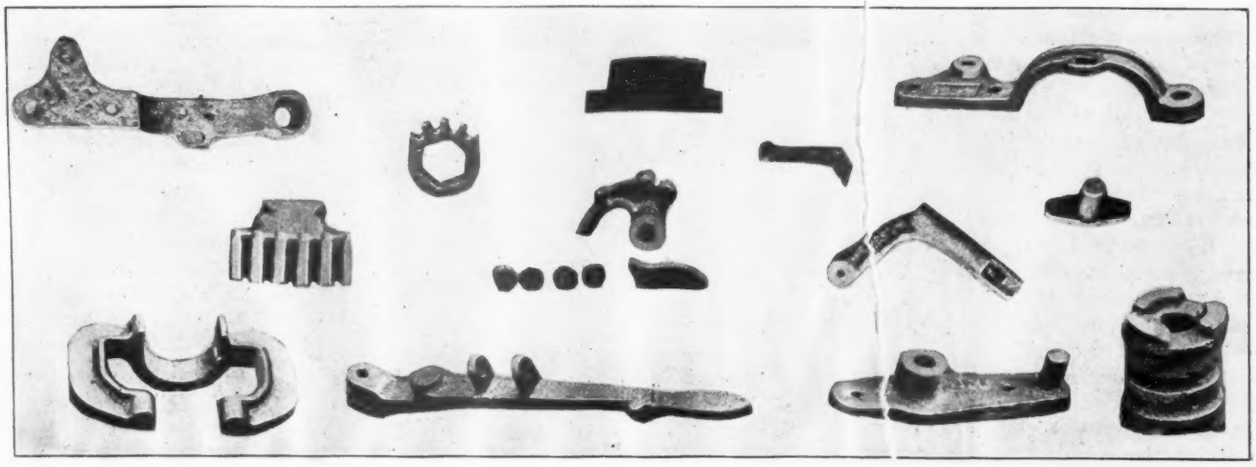


FIG. 6—MISCELLANEOUS CASTINGS MADE FROM STEEL PRODUCED IN THE TWO-TON OPEN-HEARTH

5, the materials shown in the following table were charged:

	Heat No.1 Lbs.	Heat No.2 Lbs.	Heat No.3 Lbs.	Heat No.4 Lbs.
Low phosphorus pig iron	630	680	600	650
Open-hearth scrap	1550	1700	1600	1550
Plate scrap	820	750	840	900
Ferro-manganese	15	15	15	15
Ferro-silicon	20	20	20	20
Total	3035	3165	3075	3135

The steel from every heat is analyzed and the analyses of two heats, selected at random, follow:

March 13, 1916.

	Per Cent
Carbon	0.18
Silicon	0.26
Sulphur	0.05
Phosphorus	0.035
Manganese	0.34

March 22, 1916.

	Per Cent
Carbon	0.235
Silicon	0.32
Sulphur	0.053
Phosphorus	0.035
Manganese	0.63

Castings Produced

A wide variety of miscellaneous castings is poured from every heat, both light and heavy sections being run with equal facility, which indicates that the steel is both hot and fluid, similar to that obtained in crucible operations. In Fig. 4 are shown both small and large castings poured from one heat. These castings have just been shaken-out of the sand and the teeth of the gears, it will be noted, are sharply outlined. Another sample lot of castings is shown in Fig. 6, some of the smaller pieces weighing only a few ounces each.

The Standard Crucible Steel Casting Co., in whose plant this furnace was installed, formerly produced steel by the crucible process only, but since this furnace has been operated the manufacture of crucible steel has been discontinued.

The Designers

David McLain, Goldsmith building, Milwaukee, who with Frank Carter, designed and built this small open-hearth, is well-known in the foundry trade. His experience in steel foundry work dates back to 1878, when he first began to melt crucible steel in coke-fired furnaces and subsequently artificial gas was used for fuel in furnaces of the Siemen's-Martin regenerative type. Mr. McLain served a thorough apprenticeship as a molder and worked as a journeyman for a number of years in various steel foundries. He had charge of the first plant in the United States that made steel castings by the Bessemer process, a seven-ton convertor having been employed. The converter in this plant was replaced by a 20-ton acid open-hearth furnace, which Mr. McLain operated for several years. In 1898 Mr. McLain left the Pittsburgh district for the west where he engaged in the design and construction of crucible, converter and open-hearth steel casting plants. For a period of 5½ years he was foundry superintendent of the plant of the Christensen Engineering Co., now known as the National Brake & Electric Co., of Milwaukee. Early in 1903 he began his experiments in the development of semi-steel and after leaving the employ of this company he engaged in foundry engineering work, having systematized many casting plants in the west. In 1908 he compiled a course of instruction for foundrymen, known as "McLain's System," which he since has been engaged in marketing.

Frank Carter, who is affiliated with Mr. McLain in the development of the small capacity open-hearth furnace, has had a wide experience as a steel melter at Chester, Thurlow and Pittsburgh, Pa., Milwaukee, Chicago and Minneapolis, and Montreal, Can.

Grinding Stove Plate

By Franklin W. Hobbs

The various grinding operations performed in the stove foundry consist of snagging, or grinding-off sprues, fins and bunches from the edges and corners, also fitting, which applies to doors, slides, latches, covers, etc.

Skill and judgment are required to get out good work and to keep the wheel in proper condition. Snagging may be done on a wheel of somewhat coarser cut or grit than is required for fitting. No hard and fast rule can be laid down as to the best grit and bond, because quality of iron varies so much in different foundries that a wheel that would be best for one would be wholly unsuited for the needs of another.

By some stove foundrymen a wheel having a long life is preferred, whereas the most economical wheel is worn quite fast. When a carpenter's saw or plane gets dull, it is sharpened with a file and a stone. When a wheel gets dull, the sharpening process consists of the breaking of the abrasive grains, thus forming new cutting edges, or by the bond breaking and releasing the dull particles, thus exposing fresh cutting edges, or by both. Therefore, to get best results, the abrasive material and its size of grain also the grade of bond must be suited to the work.

A soft grade of iron has a tendency to clog and glaze a wheel with a hard bond, while the hard bonded wheel would be suitable for a hard grade of iron.

Great care should be exercised in fitting wheels on arbors. If too large, they should be bushed and if too small, they should be scraped. Under no conditions should a wheel be forced upon the spindle. Thin washers of leather, rubber or cardboard should be placed between the flanges and the wheel and the nut should be screwed up firmly with a wrench. Never should a hammer be applied to the nut or the wrench.

One of the bad practices followed in some shops is to pick or chip the wheels with a cold chisel. Recently I inspected a wheel that had been subjected to such treatment. Grooves were cut across the wheel at distances of 3/16 to 1 inch, some deep and some shallow. The practice not only is liable to crack the wheel, but it is evident that it is thrown out of balance, and the uneven spacing will cause it to wear out of round.

If a wheel becomes glazed, it should be roughed with a wheel dresser. This breaks the glaze, leaving a fresh, clean cutting face.

A fitting wheel, requiring uniform corners and a true face should never be used for grinding off gates, fins, shovels, etc. If this practice is followed, the wheel soon will be in such a condition that good fitting will be impossible.

The ideal equipment for stove plate grinding consists of a rigid frame, mounted on a solid foundation; long, large bearings, nicely adjusted to prevent vibration; a grinding wheel with true face and sharp corners; a dust exhaust and a dresser to be applied once a day. Thus equipped, a man with common sense cannot fail to get out good work.

At the annual meeting of the St. Louis Foundrymen's Club officers for the ensuing year were re-elected as follows: H. S. Gulick, More-Jones Brass & Metal Co., St. Louis, president; Thomas H. Smith, Washington University, St. Louis, vice president; W. C. Roepke, Commonwealth Steel Co., Granite City, Ill., treasurer, and C. Roy Rook, U. S. Incandescent Lamp Co., St. Louis, secretary.

"The Radio Magazine" is the title of a 96-page publication issued by the Basic Mineral Co., N. S., Pittsburgh manufacturer of fluxes and amalgamators for melting and smelting iron and ferrous metals. While essentially a catalog of the products of this company, it contains a large amount of interesting information on foundry practice, melting problems, etc. The various fluxes made by this company also are discussed and many articles in a lighter vein also are presented.

New Safety Code Adopted by National Founders

Rules Prepared by this Association, which all Foundrymen Are Requested to Put Into Effect in their Casting Plants

A SAFETY code for foundries for the guidance of foundry managers in establishing safe and sanitary working conditions in their plants has been prepared by the National Founders' Association, Chicago. It was drafted with great care after extended investigations and conferences with manufacturers operating small, medium and large casting plants and melting all kinds of metals. The provisions of this code are developed on a practical basis and can be put into effect with a minimum expenditure of time and money without requiring expensive construction, changes or interference with the producing capacity of the workmen. The National Founders' Association urges every foundryman to adopt the provisions of this code in order that there may be no need for further state regulation. However, where a state foundry code is contemplated it is suggested that the one adopted by the National Founders' Association be presented for consideration and adoption. It is pointed out that neglect to follow these instructions may result in the adoption of state regulations, which usually are not so well adapted to practical foundry operations as those prepared by foundrymen who are familiar with foundry hazards and the requirements of foundry production. The three state codes adopted in New York, Pennsylvania and Ohio previously have been published in THE FOUNDRY. The safety code of the National Founders' Association is herewith presented in full:

Section 1.—A *foundry* shall mean a place where iron, steel, copper, tin, zinc, lead, aluminum or compositions containing any of these metals are melted and poured into molds for the making of castings, and shall include all molding, coremaking, melting and cleaning rooms used in connection therewith.

Section 2.—Entrances commonly used by employes during working hours for direct passage between a foundry and the outer air shall, from November first of each year to April first of the next year, be so arranged as to prevent draughts harmful to employes working within the foundry.

Section 3.—The provision of Section 2 shall not apply to entrances commonly used for horse-drawn vehicles, automobiles, mechanically-operated cars or trucks or traveling cranes; but during working hours within the period specified, such entrances may remain open for only such time as is necessary for the entrance and exit of such apparatus.

Section 4.—The floor beneath and immediately surrounding a foundry cupola shall slope and drain away from it.

Section 5.—All pits or openings located in foundry floors shall be guarded by suitable covers or railings or by watchmen.

Section 6.—The width of a gangway or aisle shall be understood to be the clear distance between molds, posts, partitions or other obstructions on one side of the gangway or aisle and similar objects on the opposite side.

Section 7.—Every gangway or aisle in which molten metal is being handled shall, during the progress of casting, be kept in good condition, clear of obstructions and free from undue dampness.

Section 8.—The floor immediately adjoining industrial tracks in gangways in which molten metal is being handled or over which workmen frequently pass shall be reasonably hard and flush with the top of the rails. Sufficient clearance for easy passage of ladle truck wheels shall be provided between the floor and rails.

Gangways

Section 9.—Where molten metal is carried in hand or bull ladles by not more than two men per ladle and poured into molds placed on both sides of the gangway, the gangway shall be not less than four feet wide, except where molds alongside the gangway are more than 20 inches high above the gangway level, in which case the gangway shall be not less than five feet wide.

Section 10.—Where molten metal is carried in hand or bull ladles by not more than two men per ladle and poured into molds placed on only one side of the gangway, the gangway shall be not less than three feet wide, except where molds alongside the gangway are more than 20 inches high above the gangway level, in which case the gangway shall be not less than four feet wide.

Section 11.—Where molten metal is carried in hand or bull ladles by more than two men per ladle, the gangway shall be not less than five feet wide.

Section 12.—Where molten metal is carried in crane, trolley or sulky ladles, the gangway shall be sufficiently wide to allow employes safely to handle and empty the ladles.

Section 13.—Where molten metal is carried in gangways on truck ladles exclusively, the gangway shall be not less than 18 inches wider than the extreme width of the truck.

Section 14.—Where molten metal is carried in crucibles by not more than two men per crucible and poured into molds placed on one or both sides of the gangway, the gangway shall be not less than three feet wide.

Section 15.—Where molten metal is carried in crucibles by more than two men per crucible and poured into molds placed on one or both sides of the gangway, the gangway shall be not less than four feet wide.

Section 16.—Where molten metal is carried in hand or bull ladles or crucibles and poured into molds on individual floors by not more than two men per ladle or crucible, an aisle not less than 12 inches wide shall be provided, except where molds alongside the aisle are more than 20 inches high above the aisle level, in which case the aisle shall be not less than 30 inches wide.

Section 17.—Where molten metal is carried in hand or bull ladles or crucibles and poured into molds on individual floors by more than two men per ladle or crucible, an aisle not less than 36 inches wide shall be provided.

Section 18.—Where molten metal is carried and poured into molds on individual floors by crane, trolley or sulky ladles, an aisle shall be provided sufficiently wide to allow employes safely to handle and empty the ladles.

Section 19.—Where the continuity of any gangway is interrupted by molds or other obstructions, the gangway shall be continued around such obstructions.

Section 20.—Where molten metal is poured into molds located in a gallery, a solid partition not less than three feet high shall be installed on the open side of such gallery.

Section 21.—The light in every foundry shall be sufficient to provide safe entrance and exit of employes and to carry on work safely during working hours.

Section 22.—The temperature in every foundry shall be maintained at not less than 50 degrees Fahr. during working hours in all sections where employes are regularly working.

Section 23.—Every foundry shall be so ventilated during working hours that smoke, gases, fumes or dust injurious to the health of employes shall, as far as practicable, be rendered harmless by means of natural circulation of air or by ventilating hoods, fans or other effective devices.

Section 24.—Hand or bull ladle bowls shall not be dried inside the foundry, except in ovens or under ventilating hoods or by means of suitable oil or gas burners.

Section 25.—No locomotive while discharging smoke shall remain inside a foundry during working hours except during such periods as may be necessary for its entrance and exit; but this regulation shall not apply to locomotive cranes.

Section 26.—No foundry in which zinc-bearing metals are melted or poured shall hereafter be installed in a room less than 14 feet in height from the lowest point of the ceiling to the floor, except that where the roof is of peak, saw-tooth, monitor or arch construction, the minimum height of the side walls may be 12 feet. If such foundry is installed in the front part of a building, the ceiling shall be in every part not less than 6 feet, 6 inches above the curb level of the street in front of the building; and if such foundry is installed entirely in the rear part of a building or extends from the front of a building to its rear, the ceiling shall be not less than three feet above the curb level of the street in front of the building, and the foundry shall open on a yard or court which shall be not less than six inches below the level of the floor.

Section 27.—If after this safety code is approved the operation of any foundry in which zinc-bearing metals are melted or poured shall be discontinued for not less than 15 consecutive days, it can thereafter be reopened for the same purpose only by complying with the provisions of Section 26.

Section 28.—Where dry tumbling mills are used within a foundry, exhaust apparatus shall be installed and operated that will effectively draw off the dust created by the operation of such mills; or the mills shall be enclosed in reasonably dust-tight compartments while in operation.

Section 29.—Where dry grinding, buffing or polishing machines are used, exhaust apparatus shall be installed and operated that will effectively draw off the dust created by the operation of such machines; but this regula-

tion shall not apply to swing-frame or portable grinding machines.

Section 30.—All castings shall, where practicable, be cleaned or chipped in rooms separated from rooms used for other purposes; but where castings are cleaned or chipped in molding or casting rooms, there shall be provided suitable screens, partitions or other effective means to protect employes against flying chips and excessive dust.

Section 31.—Sand-blasting by hand-operated apparatus shall be carried on in suitable sand-blast rooms or outside the foundry, and in the latter case effective means shall be provided to protect passers-by from the sand-blast.

Section 32.—The use of high explosives or of a drop for breaking scrap shall not be permitted unless done under reasonably safe conditions.

Section 33.—All lip-pouring ladles of 2,000 pounds capacity or more shall, within two years after this safety code is approved, be equipped with a worm-geared or other self-locking tilting device. All crane ladles, truck ladles and trolley ladles shall be so constructed that, when they are full of metal, the center of gravity shall be below the center of the trunnions, unless each ladle is equipped with a gear mechanism and a latch, either of which will prevent premature overturn of the ladle.

Section 34.—All single shank hand ladles shall be provided with sheet metal fenders.

Section 35.—When the combined weight of a crucible containing molten metal and the crucible tongs exceeds 100 pounds, the crucible shall be removed from the furnace by not less than two men or by mechanical means; and when the combined weight exceeds 300 pounds, three or more men or mechanical devices shall be employed.

Section 36.—When the crown plate of a rigid crucible furnace is located more than 12 inches above the surrounding floor, crucibles containing molten metal shall be removed from such furnace by mechanical means; or a suitable platform shall be installed, at least four feet in width, extending along the front and sides of the furnace and not more than 12 inches below the crown plate. If such platform is located 12 inches or more above the floor at the point where crucibles containing molten metal are taken from it, the crucibles shall be lowered to the floor by mechanical means.

Inspection of Appliances

Section 37.—All ladles, ladle shanks, crucibles, crucible shanks, crucible tongs, yokes, skimmers and slag hoes used in pouring of molten metal shall, prior to their use, be inspected daily in regard to their safe condition by the men preparing and using such appliances. A monthly inspection in regard to the safe condition of all crane chains, cables, ropes and slings used for suspending molten metal in mid-air shall be made by a man designated by the employer for the purpose. Reports of such monthly inspections shall be made on forms furnished for the purpose.

Section 38.—When the dust arising from cleaning operations may be injurious to the health of cleaners, they shall wear suitable respirators which shall be provided by the employer; when engaged in sand-blasting by hand apparatus, they shall, in addition, wear suitable helmets or hoods which shall be provided by the employer. When the eyes of employes are liable to injury by dust, flying chips or molten metal, employes shall wear suitable safety goggles which shall be provided by the employer. When engaged in welding or burning operations by means of an oxy-acetylene or other gas torch, employes shall wear suitable safety goggles which shall be provided by the employer; when engaged in similar operations by means of an electric arc, employes shall use suitable shields or wear suitable helmets which shall be provided by the employer. When handling molten metal, employes shall wear suitable congress type shoes which shall be provided by themselves; they shall also wear suitable leggings when these are provided by the employer.

Section 39.—No female shall be employed in a foundry unless upon examination by a competent nurse or physician it has been determined that she is of normal health, size and weight.

Section 40.—No female employed in a foundry shall lift any object exceeding 50 pounds in weight unless she uses mechanical means by which her physical effort is limited to 50 pounds.

Section 41.—Regulations affecting industrial establishments generally in respect to the safeguarding of transmission machinery, miscellaneous machinery, elevators, stairways, platforms, or relating to sanitary conveniences and first aid equipment, not included in this safety code, shall apply with equal force to foundries.

Section 42.—This safety code may be modified or suspended in whole or in part by the proper State authority in respect to existing foundries if good and sufficient reason therefor is submitted.

Preparations for Big Convention at Cleveland

TO PERMIT the foundrymen who attended the annual meetings of the American Foundrymen's Association and the American Institute of Metals, which will be held in Cleveland during the week of Sept. 11, to indulge in plant visitation to a greater extent than was possible at previous conventions where two or three sessions were held daily, it has been decided by the program committee of this organization to have one technical session per day, which will continue from 9:30 a. m. until the papers and discussions for that session have been disposed of, the hour of adjournment having been tentatively fixed at 1:00 p. m. This arrangement, it is believed, will meet with the hearty approval of all of the members of this society, and it will enable them also to devote more time to the inspection of the exhibits of foundry supplies and equipment and machine tools, which will be held concurrently with the meetings, at the Cleveland Coliseum. The conventions of these two societies will open one day earlier than formerly, the final session being held on Friday. The annual meeting of the American Foundrymen's Association, therefore, will continue for a period of five days, from Monday, Sept. 11, to Friday, Sept. 15, inclusive. The meetings of both the American Foundrymen's Association and the American Institute of Metals will be held at the Hotel Statler, which also will be the headquarters of these two societies, but the headquarters of the exhibitors will be at the Hollenden hotel.

Program Briefly Outlined

The meetings of the American Foundrymen's Association and the American Institute of Metals will be opened on Monday morning with a joint session of both societies, and the program will include the address of welcome and response; the annual addresses of the presidents of the American Foundrymen's Association and the American Institute of Metals and the reports of the secretaries of these two organizations. In addition, the representatives of the American Foundrymen's Association on the "Joint Conference Board on the Training of Apprentices" will present a report and the report of the committee on "Safety and Sanitation," also will be heard.

A joint technical session also will be held on Tuesday, the program being limited to three papers, which will constitute symposiums on the following subjects: "Waste foundry sand, its reclamation and disposal," which will be discussed in various papers that will treat the topic from different viewpoints; "Results of the closer co-operation of the engineer with the Foundry," as relating to the manufacture of aluminum and brass castings, cast iron, malleable cast iron and cast steel and "Proper gating of molds" for the manufacture of aluminum and brass castings, cast iron, malleable iron and steel castings.

The annual business meeting of the American Foundrymen's Association will be held on Wednesday morning, Sept. 18, when officers will be elected and reports of the executive committee and the auditor will be heard. Also, a report will be made by the special committee of five on the conferences which it held during the year that led up to the conduct of the exhibit under the auspices of the American Foundrymen's Association and the American Institute of Metals.

Three simultaneous sessions will be held on Thursday morning for the discussion, respectively, of gray iron, cast steel and malleable iron, while on Friday morning malleable, iron and steel sessions will conclude the

business of the convention. The program, as outlined, promises to be the best in the history of the American Foundrymen's Association, since the topics to be discussed are practical and relate to problems daily confronting the foundryman.

C. E. Hoyt, Lewis Institute, Chicago, exhibition manager, already has received a large number of applications for space and the indications are that the Cleveland Coliseum, which affords a floor area of 60,000 square feet, will be crowded to capacity. No assignments of space have yet been made, nor has a floor plan been prepared, although this will be done within the next few weeks, when the requirements of the various exhibitors approximately will be known.

A meeting of Cleveland foundrymen shortly will be held for the purpose of appointing committees for the entertainment of visitors, to serve as guides in plant visitation and for the reception and entertainment of the ladies who will attend. It is probable that the annual banquet will be held at the Statler Hotel on Thursday evening, Sept. 14. Negotiations now are being conducted to secure several speakers of national reputation to deliver addresses at the banquet.

Abrasive Costs in Snagging Castings

IN A recent article in *Grits and Grinds,* published by the Norton Co., Worcester, Mass., Wallace T. Montague ably discusses methods for obtaining adequate records on the cost of grinding. He says that among large foundries there is a tendency to use softer wheels for rough snagging work than were formerly employed. This is especially to be noticed among the concerns that grind large quantities of duplicate castings, and hence where the piece rate system of payment is in vogue, low first cost and long life are no longer the chief requisites that interest the trained and intelligent purchaser of grinding wheels. It is now recognized that rapid cutting wheels which require infrequent dressing are the most economical in the long run—wheels that are safe to operate, cheap to operate, readily duplicated and dependable in quality.

With grinding becoming more of a factor in manufacture every day, it will pay the consumer to more carefully figure his grinding costs and check them up from time to time, in order to be sure that his final abrasive cost is reduced to its lowest limit. By ***final abrasive cost*** is meant the abrasive cost per unit of output, taking wheel cost, labor cost, power and maintenance cost into consideration.

Relative Efficiency of Wheels

Where there is a constant duplication of work in large foundries and the piecework system is employed, there is a very simple but serviceable method for computing the relative efficiency of various kinds of grinding wheels. The operator's earnings on a given job per dollar cost of wheel may be considerable under these circumstances as a very fair means of determining the actual value being received for the money invested. These earnings should be averaged from the individual earnings of each operator employed on the same class of work and the data collected for a sufficiently long period of time to practically eliminate the personal factor and reduce the chances for error to a minimum.

For instance, the average earnings of several operators grinding a certain class of steel castings might be $9.00 per man in a given time and each might average to completely wear out a grinding wheel costing $6.00, which means that for every dollar cost of wheel the operator earns $1.50.

Comparative Tests

It should now be clearly established by the shop manager whether or not he is using the most economical grinding wheel for the work at hand. Comparative tests should be conducted on wheels of slightly harder or softer grades, perhaps of coarser or finer grits until the results plainly indicate that the most efficient wheel has been found. The most efficient wheel is the one that earns the most for the operator (with reasonable exertion on his part) per dollar cost of wheel to the manufacturer. When this condition exists one may be sure that the wheel is a rapid cutter, yielding high production; that wasteful dressing away of the wheel is reduced to a minimum; that the power cost, labor cost, and general maintenance cost are lower than they would be otherwise. In other words, you may be sure that you have reduced the abrasive cost per unit of production to its lowest value. When this point is reached, the manufacturer has a very good knowledge of the abrasive consumption necessary to get his work out and he can readily detect inefficient work on the part of his operators or a falling off in the quality of the grinding wheels. Of course, grinding wheels of identical composition are bound to vary slightly in their life and no two operators will get the same service out of similar wheels. The averaging of costs and earnings over a long period will take care of such variables. But marked deviation from the established costs and earnings may be brought to light and can then be intelligently investigated by the manufacturer working in conjunction with the wheel-maker.

A similar method is used in the plow industry for checking-up the abrasive cost entering into the manufacture and assembly of plows, etc., and it may be applied to other industries as well.

Suppose a 30 x 4 inch grinding wheel costs the manufacturer $51.30. When it is 26 inches in diameter it is only worth $39.30 or $12.00 worth of abrasive has been used. If the operator's earnings during that time were $15.60, the earnings per dollar cost of wheel were $1.30, whereas the minimum requirement might be $1.20. To encourage operators to use their wheels economically, a bonus is often paid for all earnings in excess of say $20.00 in using a wheel down from 30 inches to 26 inches diameter.

Wheel Removed

At 26 inches diameter the wheel is removed and placed on a machine with higher spindle speed, and the wheel worn down to 20 inches diameter. At 20 inches diameter a similar change is made to another machine with still higher spindle speed. The average wheel speed in all cases should be around 5,000 s. f. p. m. Bonuses are paid for excess earnings in all these stages and thus the maximum efficiency of use is bound to be attained.

Earnings per dollar cost of wheel should not drop below a certain carefully determined level. If they do, the superintendent knows that the wheel is either too hard and has to be dressed too frequently, or that the wheel is too soft and wears away too fast, or even that the wheel is satisfactory but is being wasted away by unnecessary dressing at the hands of an ignorant, unskilled or careless workman. Honest and capable foremen can readily determine the real cause of lowered earnings and take steps to straighten out matters.

Still a third method is used occasionally on duplicate work and with excellent results. Here also it is necessary to keep certain records carefully and a better check is obtained where the piece-work system is employed.

The following records are kept:

Date.
Pieces ground.
Weight, pounds.
Hours of grinding.
Earnings.
Wheel loss in diameter.
Abrasive consumed, cubic inches.

These figures enable the manufacturer to calculate:

The amount of abrasive consumed per ton of castings ground.

The abrasive cost per ton of castings ground.

The average earnings per hour for each operator or general average for all.

The average earnings per ton of castings ground.

Continual examination of these values keeps the superintendent thoroughly informed of the grinding costs, their fluctuations and the reasons therefor.

If a given grain and grade of wheel averages to grind a ton of castings with an abrasive consumption of 35 cubic inches, abrasive cost of $0.45, and operator's earnings of $0.28 per hour, and another grain and grade of wheel averages to grind a ton of the same castings with an abrasive consumption of 25 cubic inches, an abrasive cost of $0.32, and operator's earnings of $0.28, it is very apparent which wheel should be chosen for the work. If, on the other hand, in the second case cited, the operator's earnings per hour had fallen off materially, it would have clearly indicated that the second wheel was too hard. The decreased cost of abrasive would probably have been offset by an increased labor cost, lower production per day and a dissatisfied operator.

Earnings and Abrasive Cost

The ratio of earnings per ton of castings ground to abrasive cost per ton of castings ground should not fall below a carefully determined minimum; a bonus should be paid for excess earnings over a carefully determined maximum value of this ratio. Such figures educate the shop manager in relative abrasive costs and make him master of the situation. They absolutely point out the wheel of greatest efficiency, which is the one that will grind a ton of castings at lowest abrasive cost and highest earnings consistent with the effort of the operator.

Efficiency to the engineer, represents the ratio of output to input, expressed in the same terms. Calling the earnings of the operator per unit of production, the output, E, and the abrasive cost per same unit of production, the input, A, we derive the so-called *abrasive efficiency* factor $\frac{E}{A}$.

You are using the most efficient wheel for your work when the value of this factor is highest. Trial, alone, will prove when you have arrived at this point and the time is coming when such a factor will be submitted each month to executives along with other factors showing the departmental costs of plant operation.

Did you ever stop to consider how wasteful the average operator is when dressing rough snagging wheels? A wheel of this kind should be dressed for one of two reasons—wheel loading or glazing, or wheel out-of-round, or worn uneven on the face. By far the most frequent use of the dresser is to sharpen the wheel face, and this merely requires the removal of about 1/32 inch, just the extreme outer surface.

Power Consumption

An 18 x 2 x 1½-inch wheel might cost a concern $8 and could be used down to 8-inch diameter. This would leave about 400 cubic inches of abrasive available for work, at a cost of $0.02 per cubic inch. Suppose when this wheel is 16 inches in diameter it should require sharpening and the operator used his dresser carelessly removing ⅛ inch from the diameter of the wheel. This represents over 6½ cubic inches of abrasive valued at $0.132 and most of it is absolutely wasted. This same operation should not have cost over one-fourth that amount.

Free cutting wheels mean grinding with less exertion on the part of the operator, greater earnings and less dressing.

The question of power consumption receives very little attention at present, and yet where there are many grinding wheels at work the question will bear investigation. It requires approximately 5-horsepower to drive a grinding machine to capacity with a 24 x 2½-inch rough snagging wheel of the correct working grain and grade. It might require 5½-horsepower to drive a wheel that was long-lived and slow wearing on the same work. The freer cutting wheel will cut much faster than the hard wheel, probably from 10 to 25 per cent faster, which means that the horsepower-hours required to do a given piece of work with the freer cutting wheel, will be much lower than on the harder, long-lived wheel. Power costs money and there is no question but that the difference in the power consumption of a grinding plant using free cutting wheels and one using wheels bought chiefly on long-life specifications, will amount to several hundred dollars per year.

If a certain wheel consuming 5.25-horsepower should grind 100 castings in 10 hours and another wheel consuming 5-horsepower should grind 100 castings in eight hours, there is a saving of 12.5-horsepower-hours or 9.32 kilowatt-hours, which at $0.015 per kilowatt-hour equals $0.14. In a year this will amount to over $50 per machine. Free cutting wheels not only require less power to operate, but less cost for belting, less wear and tear on machines and equipment; in short, lower maintenance cost per unit of output. These are points that every consumer of grinding wheels would do well to consider.

True economy in the use of the grinding wheel for rough snagging work is surer to be realized when the consumer keeps adequate cost records of grinding wheel performance, uses free cutting wheels, educates his operators to use wheels properly, and rewards efficient service with a bonus.

New Electric Steel Casting Plant

The new plant of the Racine Steel Castings Co., Racine, Wis., owned by operated by the Belle City Malleable Iron Co., of that place, has been placed in operation. The plant is equipped with a three-ton Heroult electric furnace and electric steel ingots and castings will be produced. The monthly capacity of the plant is 500 tons of electric steel ingots or 300 tons of electric steel castings. A specialty also will be made of manufacturing alloy steels to specifications. The plant is 80 x 322 feet, the center bay, which is 50 feet wide, being commanded by a 7½-ton electric traveling crane installed by the Pawling & Harnischfeger Co., Milwaukee.

The Searchlight Co., 1916 Karpen building, Chicago, has issued a folder entitled "Dry Versus Wet Acetylene", in which the advantages of dry acetylene for use in welding operations is pointed out. It is claimed that so-called wet acetylene contains a solvent which burns not only at a much lower temperature than acetylene, but requires four times more oxygen than acetylene requires to produce its highest temperatured flame.

The Joseph Dixon Crucible Co., Jersey City, N. J., has increased the capacity of its crucible department by the addition of two kilns.

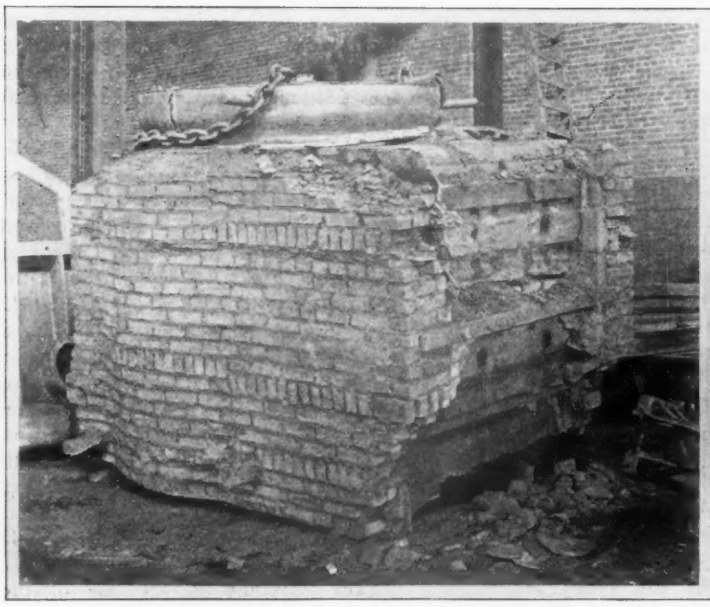


Fig. 1—Low Pressure Cylinder for Marine Engine in Loam Mold, Taken from Casting Pit to be Shaken-out

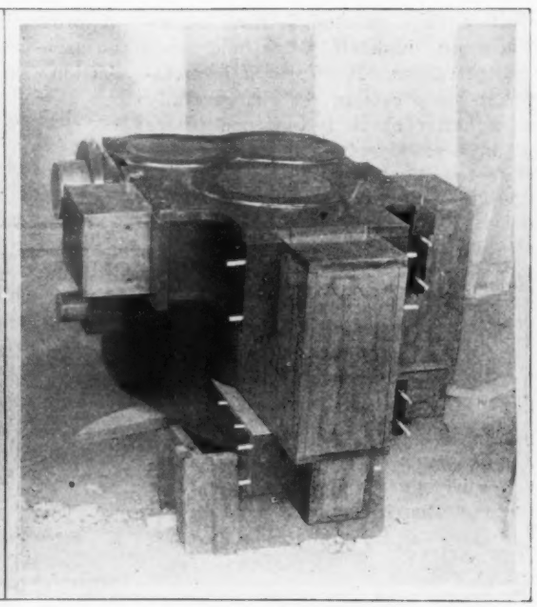


Fig. 2—The Pattern for a Circulating Pump of a Large Marine Engine

Making Castings for Great Lakes Ships

THE present world-wide shortage of merchant marine tonnage compels every ship yard in the United States to work at top speed on domestic and foreign contracts. Prospects of a phenomenally busy season at home, together with much new foreign business, have compelled Great Lakes ship builders, especially, to increase their resources as rapidly as possible. Among these improvements and additions, the large and modern foundries which today are an integral part of every first class ship yard, have come in for their share of development. In augmenting its facilities recently, the American Ship Building Co., which maintains yards and docks at Cleveland and Lorain, O., and which, through close affiliation with other organizations, commands facilities of several other lake ports, paid special attention to the construction of a new foundry at its Cleveland plant. The building of large ships of various types gives little opportunity for the establishment of a routine practice in the manufacture of large quantities of castings from the same pattern. A casting shop such as that of the American Ship Building Co. must be prepared to turn out products ranging widely in weight, design and composition, and its present arrangement and equipment is the result of many years' experience and observation.

The new plant includes a modern office building, foundry, pattern and machine shop, located at the foot of West Fifty-fourth street, near the company's slip and dry dock.

The foundry and machine shop are situated in one building, 120 x 280 feet, with a dustproof division wall. The former is shown in Fig. 3. The foundry occupies a ground area of 120 x 180 feet, while that allotted to the machine shop is 100 x 120 feet. The building is of steel construction, faced with brick laid up in black mortar. The main bay is 40 feet wide, with east and west side bays of the same width. Steel sash and ribbed glass windows of large dimensions provide excellent lighting facilities. The roof is of gypsum, with a tar paper and gravel covering. Kinnear steel doors are also provided. Equipped with one 84-inch and one 66-inch Whiting cupola, with a combined capacity of 18½ tons per hour, also with four Iller brass furnaces, the combined capacity of which is 630 pounds per melt, the foundry produces from 20 to 25 tons of cast-

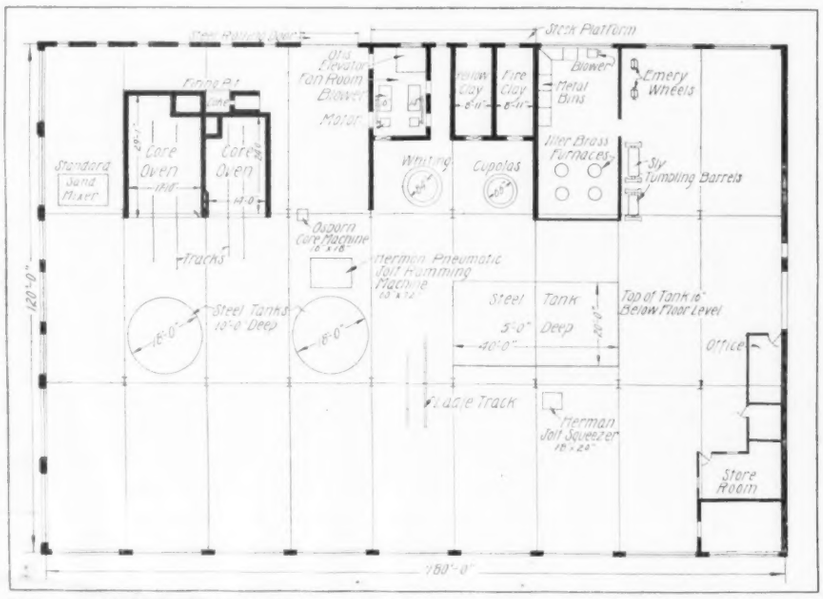


FIG. 3—LAYOUT OF FOUNDRY, AMERICAN SHIP BUILDING CO., CLEVELAND

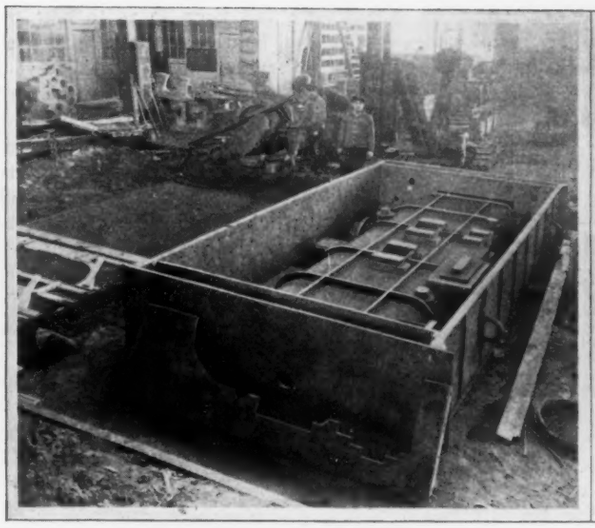


FIG. 4—CONDENSER PATTERN IN DRAG FLASK READY FOR THE SAND

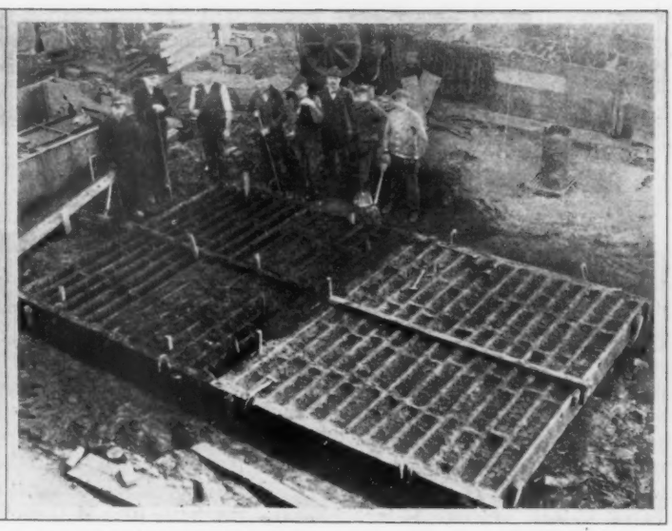


FIG. 5—PREPARING MOLD FOR BED PLATE OF MARINE INSTALLATION

ings per day, about 120 men being employed. The product of the foundry is highly diversified, including as it does every type of casting employed in the construction of a ship, from bed plates, cylinders and condensers to small fittings; the castings range upward to 15 tons in weight.

Owing to the fact that the company's plant is situated at the foot of a hill, with a consequent heavy ground moisture, pit work is taken care of in three large steel tanks set in the floor. These tanks preclude the possibility of drain water entering the molds. As shown in Fig. 3, one of the tanks is rectangular, being 20 feet wide, 40 feet long and 5 feet deep. The other two are cylindrical, being 18 feet in diameter and 10 feet deep, as shown in Fig. 6. To economize time in the use of the casting pit, large loam castings frequently are lifted from the pit before shaking-out, if their size permits, by means of a chain secured to the bottom plate of the drag, and are cleaned on the floor level, as shown in Fig. 1.

Handling Facilities

The floor is composed of cinders and 2 feet of molding sand. One 30-ton Pawling & Harnischfeger electric crane equipped with a 5-ton auxiliary hoist, one 25-ton Niles electric crane and two 7-ton electric cranes furnished by the Northern Engineering Works, Detroit, serve the foundry. The auxiliary equipment for handling materials includes two pneumatic jib cranes of the company's own manufacture.

As illustrated in Fig. 3, the foundry is furnished with two large core ovens, one approximately 17 feet wide, 29 feet deep and 10 feet high, and the other 14 feet wide, 24 feet deep and 10 feet high. These ovens, which are of the drawer type and are coke-fired, were installed by the Coleman Foundry Equipment Co., Cleveland. Comparatively few molding machines are employed, the diversity of the work precluding the possibility of routine machine practice. The machine equipment includes one Osborn 16 x 18-inch core ma-

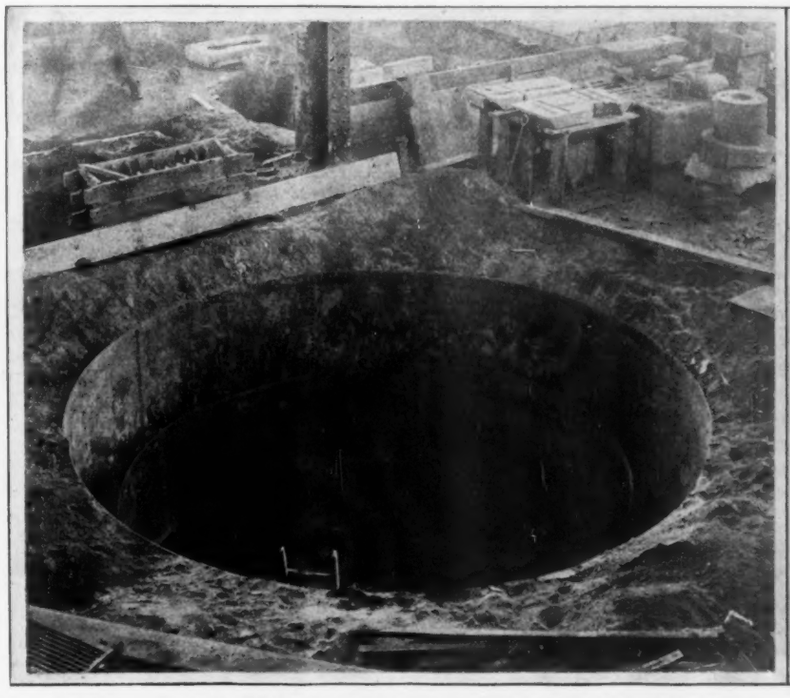


FIG. 6—CIRCULAR CASTING TANK IN WHICH LARGE WORK IS MOLDED AND CAST

FIG. 7—CENTER CORE, HIGH PRESSURE MARINE ENGINE CYLINDER

chine, one Herman 60 x 72-inch pneumatic jolt-ramming machine and one Herman 18 x 20-inch jolt-squeezing machine. Two Sly tumbling barrels with motor-driven dust arresters and a sand mixer, furnished by the Standard Sand & Machine Co., Cleveland, have also been installed.

Method of Charging Cupolas

The cupolas are charged from a steel platform, 22 x 40 feet in dimensions and 14 feet in height, extending partly into the foundry yard. In addition to a 5-ton Otis hydraulic elevator, a 10-ton Industrial crane, which is situated in the yard, may be utilized to supply the charging floor.

One 16-inch and one 14-inch blower, manufactured by the Buffalo Forge Co., Buffalo, each independently driven by a 50-horsepower Reliance electric motor, are provided. Sufficient draft can be furnished by either blower to supply both cupolas at full capacity. Five sand bins, each 10 x 10 feet in dimensions, and two clay bins, each 12 x 21 feet in dimensions, on the west side of the foundry, are so arranged as to be filled by the yard crane directly from the cars, and to discharge inside the building. Iron and coke are stored on the charging platform. The capacity of the sand bins is about 18 carloads. A large, modern lavatory with lockers and shower baths, a store room and a foreman's office are situated in the northeast corner of the foundry.

Pattern Shop and Storage

Between the office building and the foundry and machine shop building is the pattern shop and pattern storage building. It is concrete, faced with red brick and is 100 x 200 feet in dimensions. The pattern shop occupies a space of 60 x 100 feet on the ground floor at the front of the building. The remainder of the ground floor is devoted to the storage of large patterns, which it would be impossible to place on racks. The entire second floor is occupied by pattern storage racks.

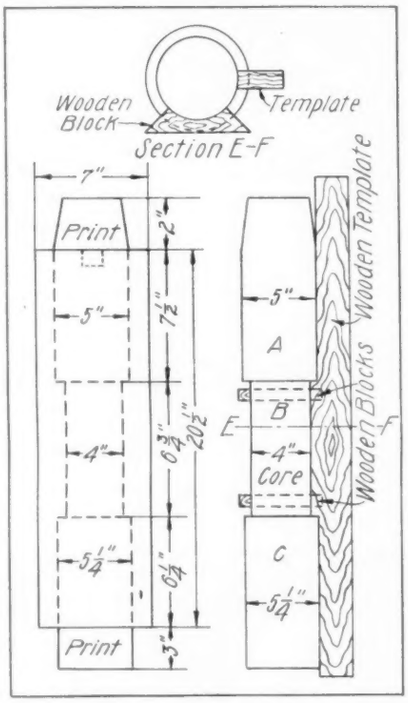
Owing to the wide diversity in the character and size of patterns required in the construction and repair work of the company, the equipment of its pattern shop is necessarily complete, including two band saws, two joiners, one pony planer, one core box machine, two stub lathes, two long lathes, two trimmers, one band saw filer and a power grindstone. Power for these tools is furnished by an electric motor. The pattern shop and storage building is equipped with steel sash of the Fenestra type and with Kinnear steel doors on both floors. About 16 men are employed.

Foundations have been laid in the foundry yard for a traveling crane, the span being 100 feet and the length of the yard 280 feet. The yard work is handled at present by a 10-ton locomotive crane.

Dull Iron Difficulties

By W. J. Keep

Question:—We are experiencing some difficulty owing to dull iron. Our melter recently left us, which undoubtedly accounts for the trouble we are having. It seemed to us that our coke bed was too high and this was reduced, dull iron resulting. On the other hand, if we get hot iron during the first half of the heat, it is dull during the last half and we do not obtain a clean drop.



HOW THE CORE WAS MADE FOR A HURRY-UP JOB

When making the first charge of iron the coke bed extends about 30 inches above the tops of the tuyeres, but if we cut this down, the first iron is not sufficiently hot for use. We charge 900 pounds of coke on the bed and 1,800 pounds of metal. We have varied the iron charges with no better results. When we drop bottom several minutes elapse before the contents drop and we have to aid this operation by the use of bars inserted through the tuyeres. There is a tradition in our shop that we must melt with a high bed. We use very little clay daubing and our cupola is smooth with straight sides. Our iron begins to spatter at the spout in about eight minutes after the blast is on.

Answer:—Light the fire about two hours before the first metal is required and let the bed burn so as to heat the bottom and lining hot enough to melt before charging iron. Make your charges as you have done in the past before you try to improve conditions. It is apparent that your tuyeres are too low to permit of slagging the cupola. I think that with a hot furnace you will have no trouble with the drop. The use of oyster shells as a flux will help you materially. Before dropping bottom insert a bar through one of the tuyeres to break the slag away so that you can see across the furnace. This should be done before bottom is dropped. Your new cupola probably will have two rows of tuyeres, but we suggest that you use the bottom row only. When you begin charging your new cupola, the top of the bed should extend 15 inches above the tops of the bottom row of tuyeres. If you experience no difficulty you can let the iron run out of the tap hole until it forms a full stream, but it is better practice to stop-up as soon as the iron runs a stream and let it accumulate until it is about 9 inches deep. Then you will have a strong stream when you tap out and you are less liable to have dull iron. With a hot cupola and a bed as described, you can make the succeeding coke charges one-tenth of the iron charges.

A Coremaking Expedient

By M. E. Duggan

A knowledge of some of the simple kinks in foundry practice frequently is of great aid to the patternmaker and to the molder in getting out a casting in the shortest possible time. Occasionally, the necessity for making a special core box will delay the production of a casting several days. In the accompanying illustration is shown a core which was made for a casting that had to be delivered promptly. Within one hour after the pattern was received the casting was poured. This, of course, would have been impossible if a special core had to be made. As shown in the accompanying illustration, the core was assembled from three stock cores of varying diameters and pasted together, as shown in the illustration at the right. The stock cores had diameters of 4 inches, 5 inches and 5¼ inches, and pieces, respectively 6¾ inches, 9½ inches and 9¼ inches, were cut and assembled by the use of small wood blocks under the center core and the straight edge templet. The core was quickly assembled and pasted. The pattern of course had to be molded on end because it was the only way that the work could be done by the use of a core made in this way.

Variable Factors in Malleable Iron Production

An Outline to Illustrate Their Inter-Dependent Relationship, With Side-Lights on the Manufacture of this Ductile Material

By L. E. Gilmore

THE accompanying outline may be useful as a guide for systematic study and research in malleable iron. A definite outline for study of any subject is a time-saver. When the whole subject is summarized in a page, giving as it were, a bird's-eye view, the influence of each detail on the whole is more quickly grasped, and the inter-dependent relationship of the various factors affecting the product is more readily understood.

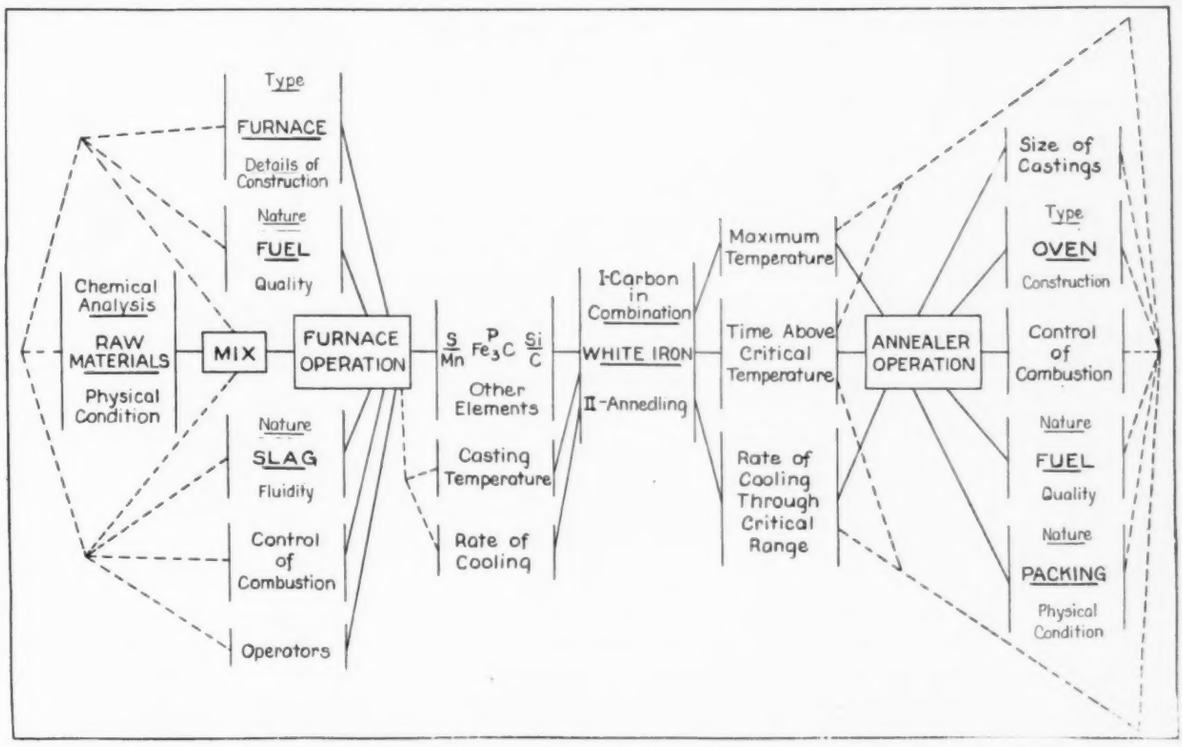
In addition, this outline may be used to assist in assigning causes for defective product, as, by first having in outline the various items that may be the cause for defects, we can test and reject one after another and finally reach a true conclusion. Instead of this method, we so often see a cause hastily assigned which, while plausible at face value, proves utterly erroneous if subjected to the several tests now available in chemical and microscopic analyses.

In the production of malleable, there are two requisites: First, the carbon of the white iron must be in chemical combination, and in such combination that it is annealable, and second, the annealing must be such as will dissociate the carbon in combination, as precipitated free carbon. On the other hand, these two requisites may be expressed in the one statement, that the white iron must be of such microscopic structure that proper heat treatment will precipitate the carbon present in the form of temper carbon. All the variables preceding and during casting must be manipulated to attain the first mentioned condition and all the variables of the annealing operation must be regulated to produce the second requisite. Starting, then, with these two requisites as a basis, the outline works from the center backward, so to speak, to the raw materials, and forward to the finished product.

For the production of a white iron with carbon so combined as to properly anneal, the outline shows three main divisions directly responsible for the condition of the carbon; the chemical analysis or inter-dependent relationship of the chemical elements present, the casting temperature, and the rate of cooling.

Taking into consideration the last two divisions; other variables being constant, the higher the casting temperature, the greater the percentage of combined carbon. Likewise, the faster the rate of cooling, the greater the percentage of combined carbon. The casting temperature is largely determined by both furnace operation and length of time of holding in ladle after tapping. The rate of cooling may be modified by a number of factors such as thickness of section of casting, time of dumping of molds, artificial chills and casting temperature. The higher the casting temperature, the greater the rate of cooling.

From a metallurgical point of view, of still greater importance than the casting temperature and rate of cooling, is the chemical analysis and microstructure of the hard white iron. The condition of the carbon is largely determined by the inter-dependent re-



CONTROL CHART OF MALLEABLE CAST IRON, MELTING AND ANNEALING OPERATIONS

Presented at the Atlantic City convention of the American Foundrymen's Association.

lationship of the various elements present; the carbon-silicon relationship, the manganese-sulphur proportions, and the effect of any other elements which may be present. Other conditions being constant, the proper condition of combined carbon may be secured by widely varying percentages of silicon, provided the carbon is correspondingly reduced as the silicon percentage is increased. Likewise, black heart malleable may be produced from white iron of varying percentages of sulphur, provided the manganese is correspondingly manipulated. In experimenting with the addition of chemical elements not so commonly met in malleable, and even with increases of the elements usually present, the investigator may easily be misled into false conclusions unless every detail is carefully taken into account. For instance, the alloy used to add a certain element to the mix may contain a sufficient percentage of another element so that the effect produced is due to the second element rather than to the first. Certain ferro-alloys have sufficient carbon to gray the white iron, irrespective of the effect of the other elements present in the alloy.

The next step back toward the raw materials is furnace operation. This operation is dependent upon a number of variables, five of which will be considered: First, type of furnace and details of construction, (these might be considered constant, after once adopting a certain type); second, kind and quality of fuel used; third, nature of slag; fourth, control or lack of control of combustion; fifth, the men in charge of the furnace operation.

Types of Furnaces Used

The following types of furnaces have been used for producing malleable: Crucible, cupola, air, open-hearth, converter, electric, duplex—or combination of two of the foregoing types. The type of furnace is of utmost importance, and the use of a certain type imposes rigid limits on the chemical composition requisite for the successful production of black heart malleable. In the cupola furnace using the average coke on the market, the molten iron as it comes in contact with the coke, absorbs both carbon and sulphur. This immediately determines that with the high carbon and high sulphur, we must have low silicon and high manganese. On the other hand, in the other types of furnaces, more leeway is possible, especially in manipulating the percentages of carbon and silicon. However, even in these types, since sulphur and phosphorus are usually changed comparatively little from the mixes, the furnaces limit the percentages of manganese, sulphur and phosphorus, while allowing greater flexibility in percentages of carbon and silicon.

Not only has the type of furnace a predominating influence on its operation, but details of construction, which may be varied, place limitations on methods of operation. For example, the air furnace may be arranged for natural draft, or for forced draft under the grates, with or without an auxiliary air supply over the front bridge. Each of the infinite variety in details of construction of the different types will have its modifying influence on furnace operation.

Quality of Fuel Used

Certain details of construction determine the nature of the fuel used. Cupolas have been equipped to burn coke, coal or oil. Open-hearths may be fired with producer gas, natural gas or oil. The air furnace usually burns coal, but could be arranged to be fired with powdered coal, oil or gas. Crucibles may be heated by nearly all fuels, while converters require no fuel at all, unless the cold charge be melted in the converter prior to blowing.

Not only the nature, but also the quality, of the fuel, greatly affects the furnace operation. A coke too high in ash and sulphur might make impossible the production of good malleable in a cupola. In the air furnace, a high fusible ash coal might present great difficulties. The amount of heat energy available and the speed with which it can be developed and applied in useful work of melting, are factors entering into the choice of fuel and operation of the furnace.

Another important factor in furnace operation is the nature and condition of the slag. The retention or loss, and the speed of elimination of certain chemical elements, may be largely dependent upon the slag. A basic slag would be required to reduce sulphur and phosphorus. The fluidity of the slag is of the greatest importance. In cupola operation, a too viscid slag may bring disaster to the heat through clogging. In the air furnace and open-hearth, the presence of considerable amounts of basic materials such as iron oxide or lime will make a fluid slag difficult to skim and one that rapidly removes silicon and manganese from the molten metal.

The next item noted in furnace operation is control of combustion. The method employed is determined by the various factors already mentioned, such as type of furnace, details of construction, nature and quality of fuel, and in addition, the skill of operators.

Whether or not all other factors are favorable to the production of best quality, human nature has the final word in furnace operation. Under certain methods of operation some men may produce a quality of iron impossible for others under like conditions, due, naturally, to the differing natures and idiosyncrasies of men. Harmony and co-operation between members of an organization have a profound influence on efficient furnace operation. So the human factor assumes an importance quite as great as any of the other variables with which we have to deal.

The whole subject of furnace operation may be summarized in two aims: That of melting the iron in the shortest possible time at least cost, and that of producing an iron hot enough to pour the work successfully.

Having settled on the type of furnace, and details of construction being fixed, the question now is, what mix will produce the analysis of best composition. Here again the mix is dependent upon the method of operation or *vice versa*, and very probably both may be dependent upon materials available.

The Ideal Mixture

The ideal mix is that which will produce, under the conditions of furnace operation, the desired composition in the melted iron as soon as the iron is hot enough for pouring. Malleable mixes are commonly made up of one or more of the following irons: Pig, white iron such as sprues and scrap, annealed scrap, steel, wrought iron and gray iron scrap. The making of a good mix is not as simple as it might at first appear. To make one properly, practically every item so far considered in this discussion must be taken into consideration. First, the chemical composition required to produce the desired quality of white iron must be known. Then, the losses or increases in each element due to furnace conditions and methods of operation must be discounted. This gives the desirable composition for the mix, which must then be approximated as closely as possible from the materials available. The amount and nature of scrap that can be used will depend largely upon its own chemical composition and that of the various grades of pig available. For example, the use of a high carbon pig such as charcoal, would carry more low carbon material in the shape of steel. The point to

be kept in mind is to mix so that all the elements will be in proper proportions—to mix with all elements in mind and not specifically for one element.

Likewise, the physical condition of the scrap and pig is a variable that has an important bearing upon the use of these materials. These physical variables are such factors as size of pieces to be melted and the condition and amount of surface exposed to the fusing action. Material such as sand-coated pig requires greater length of time for melting. The more chunky the pieces of metal (since less surface is exposed to the heat) the longer the time required for melting. As the chemical composition approaches pure iron, the difficulty of fusion increases. On the other hand, very small pieces of metal which offer large surfaces may be detrimental when badly rusted. This rust, as well as all the loose sand charged with iron must be taken care of in the slag.

Thus it is clear that factor upon factor act and react, one upon another, and each must be considered in its various and variable effects. At the same time, all factors must be taken into consideration as a whole.

Importance of Heat-Treating

Having once produced a satisfactory white iron with all the elements in such proportions that the carbon may be properly precipitated by annealing, there still remain the variables of the heat-treatment to make or mar the product.

The essentials of the annealing operation are: First, the maximum temperature attained; second, length of time held above the critical temperature; and third, the rate of cooling through the critical range. The thickness of castings and nature of packing used are variables which modify the three main essentials.

As in the case of the melting furnaces, the type and details of construction of the annealing furnace are mechanical features that have a great bearing on the production of desired quality. The annealer may be of a muffle type, or open to the direct action of the flame. Various fuels may be used, as anthracite or bituminous coal, powdered coal, oil or gas. The aim in the construction of the annealer and in the application of fuel, is to furnish a means for rapidly heating the castings in all parts of the oven to as nearly a uniform temperature as possible, and then maintaining this temperature a suitable length of time. Most ovens in actual use fall far short of this ideal, and the fuel, its quality and the operation of the furnace, are of vital importance. In most cases certain parts of annealers reach high temperature hours ahead of other parts, and because of this, it is important to pack the oven so that the castings of greater thickness will receive the greater heat or be held a greater length of time at an annealing temperature.

The variables of the annealing operation are interdependent just as are the factors for producing the white iron. For instance, within limits, an increased maximum temperature and shorter holding time may accomplish the same result as a lower maximum temperature with a longer holding time. The use of certain packing materials, or the fineness of this material, may impose a condition of lower temperature. Annealing in an oxidizing, neutral, or reducing packing or atmosphere, will materially affect the toughness of the casting.

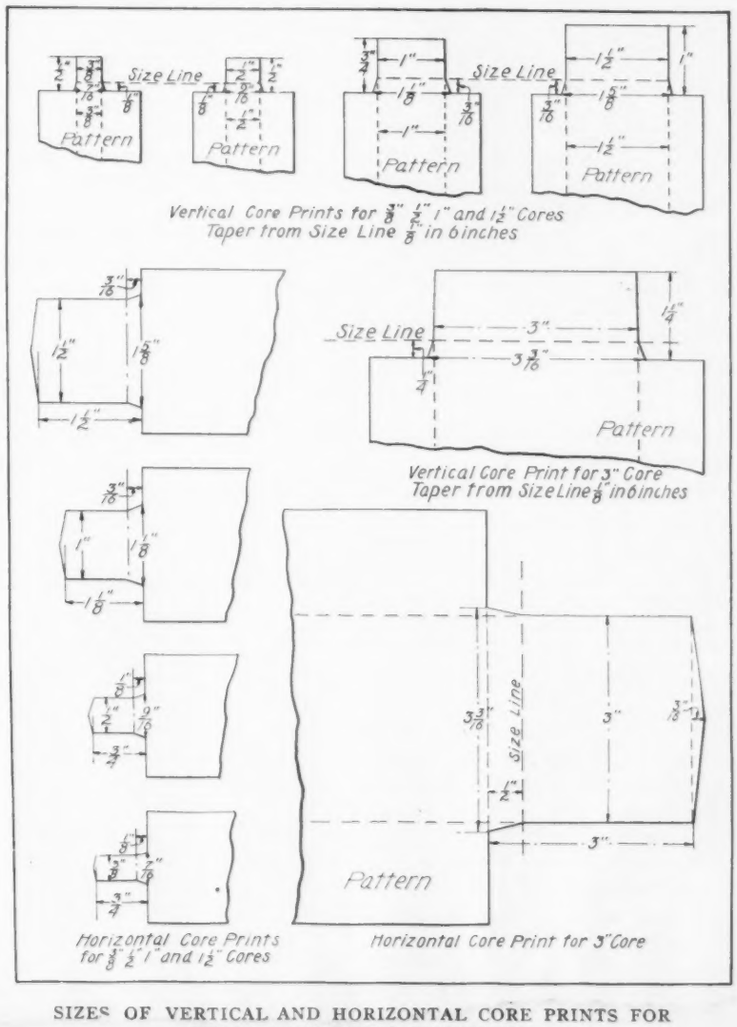
The rate of cooling through the critical range may make or mar an otherwise perfect material. And so it goes.

The successful and economical production of best quality malleable iron is impossible without a comprehensive grasp of the fundamental principles underlying the actions and reactions of the various factors on every step and operation of its manufacture.

The Tapering of Core Prints

By Edward Grant

IN THE January, 1916, issue of THE FOUNDRY, page 28, F. J. Townsend suggested the advisability of discussing the tapering of core prints and I agree with him that the American Foundrymen's Association should consider this problem and should devise a set of standards, both as to the length and taper of core prints, for cores of different sizes, both vertical and horizontal. There is a rule that the bottom core prints should be


Size Line
Pattern
Vertical Core Prints for 3/8" 1/2" 1" and 1 1/2" Cores
Taper from Size Line 1/8" in 6 inches
Size Line
Pattern
Vertical Core Print for 3" Core
Taper from Size Line 1/8" in 6 inches
Size Line
Pattern
Horizontal Core Prints
for 3/8" 1/2" 1" and 1 1/2" Cores
Horizontal Core Print for 3" Core

SIZES OF VERTICAL AND HORIZONTAL CORE PRINTS FOR CORES OF VARIOUS DIAMETERS

given a taper of ⅛ inch per foot, the same as patterns, and the top prints ⅛ inch in 4 inches, and I presume that Mr. Townsend is working to this rule. However, I would like to make a suggestion, namely, that the vertical core print, both top and bottom, be tapered ⅛ inch in 6 inches to a point ¼ inch from where it rests on the pattern, but from this point it should expand and should be tapered, depending on the size of the core, 1/64, 1/32, 1/16 or ⅛ inch larger than the actual size of the core. This would insure an opening of right size extending the full length of the casting without incurring the danger of crushing the mold, if ordinary care is exercised in tapering the cores the proper distance. This might result in a slight fin, but the old adage, "A fin before a crush" applies in this case. The making of such cores in halves and then pasting them together is simply absurd in this day and age of core machines and gang core boxes, and any molder worthy of the name will taper a

FIG. 1—LOCOMOTIVE DRIVING BOX WITH BRASSES CAST IN PLACE

core in one-twentieth the time it takes to paste and dry a split core.

There is another rule, where it originated I don't know, but I think it absurd. It refers to the length of core prints and provides that both cope and drag prints should equal three-fourths the diameter of the core. This may be satisfactory for a core 1 or 1½ inches in diameter, but for a core ⅜ or ½ inch in diameter, to say the least, it is somewhat annoying.

Every molder knows that a vertical core, 3 or 5 inches in diameter, ordinary length, will set as well and will be as safe in a print ½ inch long as in a print 2 or 3 inches long. It also is my contention that horizontal cores should have prints at least half as long again as vertical cores. For horizontal core prints, from 1½ inches up to 5 inches, the prints should be as long as they are wide, but naturally there would be exceptions to this rule for general jobbing work. In the accompanying illustration on the previous page, are shown vertical core prints for ⅜, ½ and 1½-inch cores, cope and drag prints to be the same size; horizontal core prints for ⅜, ½ and 1½-inch cores; a vertical core print for a 3-inch core, the prints for cope and drag to be the same, and a horizontal core print for a 3-inch core.

Smelting Gold and Silver in a Brass Furnace

By H. H. Miller

Down here in Torreon, Mexico, many subterfuges must be resorted to in melting and smelting operations and recently I had an opportunity to utilize a brass furnace for smelting gold and silver. None of the large mines nor any of the smelters in this vicinity is operating at the present time and the few who are working mines on a small scale experience unusual difficulties in smelting their ores. Some time ago several assayers and mining men requested me to smelt some concentrates for them and this was done under their direction. The concentrates were charged into the crucible of the brass furnace with bicarbonate of soda, borax and powdered glass. When the pot was lifted from the fire most of the slag was skimmed off and the metal was poured into green sand molds. The slag that still remained formed a layer on top of the ingots and when cold was easily broken off, leaving the bars of silver clean and smooth. I was informed that the metal also carried a high percentage of gold. I took off three small heats, recovering 55 pounds of the metal in bars and the assayers and mining men expressed themselves as being highly pleased with the results. However, when I figured the cost of this operation on a United States gold basis and presented the figures to them, they decided that the operation was too expensive and this probably will be my last, as well as my first, experiment in that line.

Casting Brass Liners in Locomotive Driving Boxes

By F. West

The use of detachable brasses in locomotive driving boxes is practically obsolete. The method now pursued in lining the boxes is to cast the brass directly onto the surfaces, as shown in Fig. 1. The cast iron boxes first are machined on the two exterior flat sides, one for the shoe surface, and the other for the wedge. One of these machined surfaces is illustrated in Fig. 2. The machining consists of cutting suitable grooves and in drilling a row of holes, 1-inch or larger in diameter, where a special grip on the brass is needed. A row of these holes is shown at *X*, Fig. 2, and grooves, at *Y*.

The inside surface, forming a semicircle in the top of the box, is machined on a shaper. At least three, wide and deep dovetailed grooves, are cut the full length of the bearing. On the end face of the bearing that comes next to the driving wheel hub, a row of holes is drilled to aid in securing the brass facing which is about 1 inch in thickness. This facing is cast solid with the interior brass. The bearing brass is cast 3 or 4 inches thick with the oil channels crossed, as shown in Fig. 1.

In Fig. 2, is shown a machined box ready for pouring the inside brass, together with the end flange. The box is set on a metal plate near the furnaces. A heavy, hollow cast iron mandrel, *A*, is placed in the opening to give the proper thickness of brass in the semi-circular bearing. The brass is stopped-off at the right location by

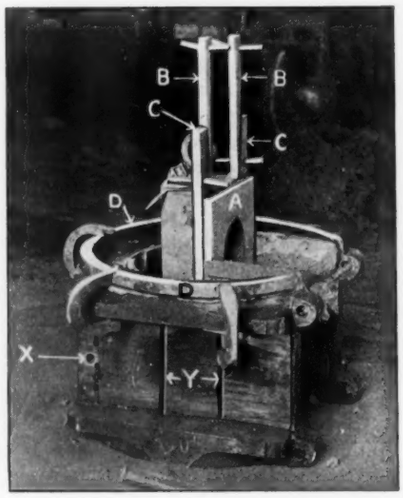


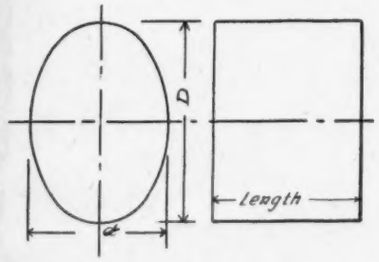
FIG. 2—LOCOMOTIVE DRIVING BOX SET UP FOR CASTING BRASS LINER

two steel spacing bars, *B*. The other bars, *C*, serve as wedges behind the outer bars, *B*. The mold cavity for the end of the brass is formed by a horseshoe-shaped frame, *D*, made of 1-inch steel, clamped to the end of the box as shown. This frame is bedded in clay to form a metal-tight joint.

Before setting up the box for pouring it is heated in a gas-fired, circular stove, the side of which is sheet steel and the top cast iron. The outside mold for the driving box is made of heavy plates to give the brass the flat surface and form, shown in Fig. 1. The box then is returned to the machine shop where the shoe, wedge, and hub surfaces are planed and the axle bearing bored. In this style of box the brasses are held in place for *keeps*. With the device illustrated the pouring of these brasses is performed expeditiously.

WEIGHT OF ELLIPTICAL BARS PER RUNNING INCH.

By W. L. Tryon



To find the weight of an elliptical bar of any length multiply the weight per running inch obtained from table by the length.

d	D	Weight Per Running Inch When Cast in Cast iron	Steel	Alum-inum	Cop-per	Zinc	Gun metal	Yel'w brass
¾	1	.153	.167	.057	.188	.149	.185	.178
¾	1¼	.192	.208	.076	.235	.187	.232	.223
¾	1½	.230	.250	.085	.282	.224	.278	.268
¾	1¾	.268	.292	.099	.329	.261	.324	.312
¾	2	.306	.334	.113	.376	.298	.370	.357
¾	2¼	.344	.376	.128	.423	.336	.416	.402
¾	2½	.382	.417	.142	.470	.373	.463	.447
¾	2¾	.421	.459	.156	.517	.410	.509	.491
¾	3	.459	.501	.170	.564	.448	.555	.535
1	1¼	.255	.278	.095	.314	.248	.310	.298
1	1½	.306	.334	.114	.376	.297	.372	.357
1	1¾	.357	.390	.132	.439	.347	.434	.416
1	2	.408	.446	.151	.502	.396	.496	.476
1	2¼	.459	.502	.170	.565	.446	.558	.535
1	2½	.510	.557	.189	.628	.495	.620	.595
1	2¾	.561	.613	.208	.690	.545	.682	.655
1	3	.612	.669	.227	.753	.595	.744	.715
1	3¼	.663	.725	.246	.816	.644	.806	.774
1	3½	.715	.780	.265	.879	.694	.868	.834
1	3¾	.766	.836	.284	.942	.743	.930	.893
1	4	.817	.892	.303	1.01	.793	.992	.952
1¼	1½	.384	.417	.142	.470	.372	.464	.445
1¼	1¾	.448	.487	.165	.548	.434	.542	.519
1¼	2	.512	.556	.189	.626	.496	.620	.594
1¼	2¼	.576	.626	.212	.706	.558	.697	.668
1¼	2½	.640	.695	.236	.785	.620	.774	.742
1¼	2¾	.704	.765	.260	.863	.682	.851	.815
1¼	3	.768	.835	.284	.941	.744	.929	.890
1¼	3¼	.832	.905	.307	1.02	.806	1.01	.965
1¼	3½	.896	.975	.331	1.10	.868	1.09	1.04
1¼	3¾	.960	1.04	.354	1.18	.930	1.16	1.11
1¼	4	1.02	1.11	.378	1.26	.992	1.24	1.19
1¼	4¼	1.09	1.18	.402	1.33	1.06	1.32	1.26
1¼	4½	1.15	1.25	.425	1.41	1.12	1.40	1.34
1¼	4¾	1.22	1.32	.448	1.49	1.18	1.47	1.41
1¼	5	1.28	1.39	.472	1.56	1.24	1.55	1.48
1½	1¾	.535	.585	.198	.660	.520	.650	.625
1½	2	.612	.669	.226	.754	.595	.744	.714
1½	2¼	.689	.753	.255	.848	.670	.836	.803
1½	2½	.765	.836	.283	.942	.744	.930	.892
1½	2¾	.843	.920	.312	1.04	.819	1.02	.981
1½	3	.920	1.00	.340	1.13	.893	1.12	1.07
1½	3¼	.996	1.09	.368	1.23	.967	1.21	1.16
1½	3½	1.07	1.17	.396	1.32	1.04	1.30	1.25
1½	3¾	1.15	1.25	.425	1.41	1.11	1.39	1.34
1½	4	1.23	1.34	.453	1.51	1.19	1.49	1.43
1½	4¼	1.30	1.42	.481	1.60	1.26	1.58	1.52
1½	4½	1.38	1.50	.510	1.70	1.34	1.67	1.61
1½	4¾	1.46	1.59	.538	1.79	1.41	1.77	1.70
1½	5	1.53	1.67	.566	1.89	1.49	1.86	1.78
1½	5¼	1.61	1.75	.594	1.98	1.56	1.95	1.87
1½	5½	1.69	1.84	.623	2.07	1.63	2.05	1.96

(*Continued on Data Sheet No.* 210.)

WEIGHT OF ELLIPTICAL BARS PER RUNNING INCH.

By W. L. Tryon

(*Continued from Data Sheet No.* 209.)

d	D	Weight Per Running Inch When Cast in Cast iron	Steel	Alum-inum	Cop-per	Zinc	Gun metal	Yel'w brass
1½	5¾	1.76	1.92	.651	2.17	1.71	2.14	2.05
1½	6	1.84	2.00	.680	2.26	1.78	2.23	2.14
1¾	2	.715	.780	.265	.879	.694	.866	.832
1¾	2¼	.806	.876	.298	.988	.782	.975	.917
1¾	2½	.895	.975	.331	1.10	.867	1.08	1.04
1¾	2¾	.985	1.07	.364	1.21	.955	1.19	1.14
1¾	3	1.08	1.17	.397	1.32	1.04	1.30	1.24
1¾	3¼	1.16	1.27	.430	1.43	1.13	1.41	1.35
1¾	3½	1.25	1.37	.463	1.54	1.21	1.52	1.45
1¾	3¾	1.34	1.47	.496	1.65	1.30	1.63	1.55
1¾	4	1.43	1.56	.530	1.76	1.39	1.74	1.65
1¾	4¼	1.52	1.66	.563	1.87	1.47	1.84	1.75
1¾	4½	1.61	1.76	.596	1.98	1.56	1.95	1.86
1¾	4¾	1.70	1.86	.629	2.09	1.65	2.06	1.96
1¾	5	1.79	1.95	.662	2.20	1.74	2.17	2.06
1¾	5¼	1.88	2.05	.696	2.31	1.82	2.28	2.16
1¾	5½	1.97	2.15	.729	2.42	1.91	2.38	2.26
1¾	5¾	2.06	2.25	.762	2.53	1.99	2.49	2.36
1¾	6	2.15	2.34	.795	2.64	2.08	2.60	2.46
1¾	6¼	2.24	2.44	.828	2.75	2.16	2.71	2.57
1¾	6½	2.33	2.54	.861	2.86	2.25	2.82	2.67
1¾	6¾	2.42	2.64	.894	2.97	2.34	2.93	2.77
1¾	7	2.51	2.74	.927	3.08	2.42	3.04	2.88
2	2¼	.920	1.00	.341	1.13	.891	1.12	1.07
2	2½	1.02	1.11	.378	1.25	.990	1.24	1.19
2	2¾	1.13	1.23	.416	1.38	1.09	1.36	1.31
2	3	1.23	1.34	.455	1.50	1.19	1.49	1.42
2	3¼	1.33	1.45	.493	1.63	1.29	1.61	1.54
2	3½	1.43	1.56	.530	1.75	1.39	1.73	1.66
2	3¾	1.53	1.67	.568	1.88	1.48	1.86	1.78
2	4	1.64	1.78	.606	2.00	1.58	1.98	1.90
2	4¼	1.74	1.89	.644	2.13	1.68	2.11	2.02
2	4½	1.84	2.00	.682	2.25	1.78	2.22	2.14
2	4¾	1.94	2.11	.720	2.38	1.88	2.36	2.26
2	5	2.04	2.22	.758	2.50	1.98	2.48	2.38
2	5¼	2.15	2.34	.796	2.63	2.08	2.60	2.49
2	5½	2.25	2.45	.834	2.75	2.18	2.72	2.61
2	5¾	2.36	2.56	.871	2.88	2.28	2.86	2.73
2	6	2.46	2.67	.909	3.00	2.38	2.98	2.85
2	6¼	2.56	2.78	.956	3.13	2.48	3.10	2.97
2	6½	2.66	2.89	.985	3.25	2.58	3.22	3.08
2¼	2½	1.16	1.26	.425	1.41	1.11	1.39	1.33
2¼	2¾	1.27	1.38	.467	1.55	1.22	1.53	1.47
2¼	3	1.39	1.51	.510	1.69	1.33	1.67	1.60
2¼	3¼	1.50	1.63	.552	1.83	1.45	1.81	1.73
2¼	3½	1.62	1.76	.595	1.97	1.56	1.95	1.87
2¼	3¾	1.73	1.88	.638	2.12	1.67	2.08	2.00
2¼	4	1.85	2.01	.680	2.26	1.78	2.22	2.13
2¼	4¼	1.96	2.14	.723	2.40	1.89	2.36	2.26
2¼	4½	2.08	2.26	.765	2.54	2.00	2.50	2.40
2¼	4¾	2.19	2.39	.808	2.68	2.11	2.64	2.53
2¼	5	2.31	2.51	.850	2.82	2.22	2.78	2.67
2¼	5¼	2.42	2.64	.894	2.96	2.33	2.92	2.80
2¼	5½	2.54	2.76	.936	3.10	2.44	3.06	2.93
2¼	5¾	2.66	2.89	.979	3.24	2.55	3.20	3.07
2¼	6	2.77	3.02	1.02	3.38	2.66	3.34	3.20
2¼	6¼	2.89	3.14	1.06	3.53	2.77	3.47	3.34
2¼	6½	3.00	3.26	1.10	3.67	2.89	3.61	3.47
2¼	6¾	3.12	3.39	1.15	3.81	3.00	3.75	3.60
2¼	7	3.24	3.52	1.19	3.95	3.11	3.88	3.73
2½	2¾	1.39	1.53	.519	1.72	1.37	1.70	1.63
2½	3	1.53	1.67	.566	1.88	1.49	1.86	1.78
2½	3¼	1.66	1.81	.614	2.04	1.61	2.01	1.93
2½	3½	1.78	1.95	.661	2.19	1.74	2.16	2.08
2½	3¾	1.91	2.08	.709	2.34	1.86	2.32	2.23
2½	4	2.04	2.22	.756	2.50	1.98	2.48	2.38
2½	4¼	2.16	2.36	.802	2.66	2.11	2.63	2.52
2½	4½	2.29	2.50	.850	2.82	2.24	2.78	2.67
2½	4¾	2.42	2.66	.896	2.98	2.36	2.94	2.82
2½	5	2.54	2.78	.945	3.13	2.48	3.09	2.97
2½	5¼	2.67	2.92	.991	3.29	2.66	3.25	3.12
2½	5½	2.80	3.06	1.04	3.44	2.73	3.40	3.26

Note—This sheet may be cut into two sections, 5 x 7 inches, and may be readily bound in note-book form.

THE FOUNDRY DATA SHEET, MAY, 1916

Payment will be made for all contributions on foundry and pattern shop practice suitable for publication

THE BRASS FOUNDRY

Permanent Molds for Non-Ferrous Metals

AT A recent meeting of the Birmingham (Eng.) branch of the British Foundrymen's Association, F. Johnson, principal of the Birmingham Technical School, presented an exceedingly interesting paper entitled "The Casting of Non-Ferrous Metals in Chill Molds". In introducing his subject, Mr. Johnson pointed out that only in instances in which superior mechanical properties are required is the chilled casting indispensable, and he stated that the speed of production compares unfavorably with that of the pouring of castings in sand. The advantages claimed for chilled non-ferrous castings are improved mechanical properties, due not so much to the chilling action as to the absence of porosity; the elimination of labor required in sand molding; the ease with which the casting can be removed from the mold and the mold again prepared for another casting; the suitability of this process for repetition work and the economy effected in the production of a very limited amount of scrap. The disadvantages consist of a reduced output unless organized for repetition work; inferiority of surface, unless conditions are ideal, necessitating additional machining; the difficulty of coring intricate parts and the initial cost of the mold and its slow deterioration in use. He emphasized, however, that the great advantage of chilled castings over sand castings is the marked superiority in mechanical properties. Mr. Johnson added, however, that the common belief that this superiority is due to the chilling action of the mold, producing rapid solidification and cooling, requires considerable modification. Continuing, he spoke as follows:

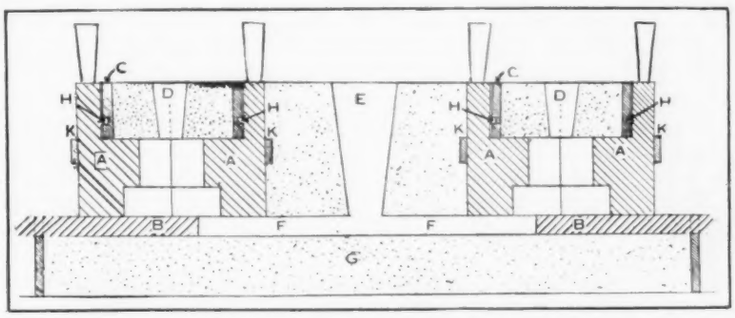


FIG. 2—CROSS-SECTION OF A GROUP OF PERMANENT IRON MOLDS ARRANGED IN A CIRCLE

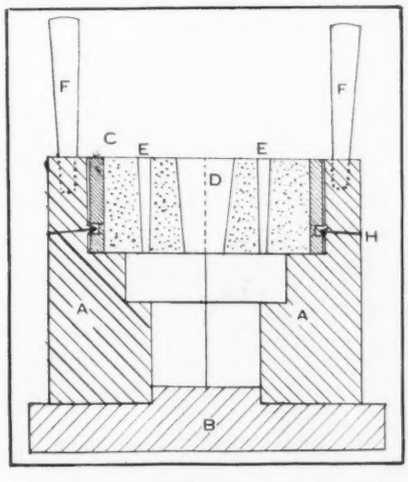


FIG 1—CROSS-SECTION OF PERMANENT IRON MOLD FOR NON-FERROUS METALS

"Unlike iron-carbon alloys, the brasses and bronzes do not possess an intensely hard constituent which is retained by rapid cooling. In the case of brass containing the Beta phase, relatively more of this strong constituent probably is retained by the rapid cooling of a chill casting than by the slow cooling of a sand casting. The improvement in mechanical properties due to this fact cannot be regarded as important. In the case of copper-tin alloys, relatively more of the Delta phase would be retained in a chill casting. There is, however, another consideration involved in rapidity of solidification, and that is introduced by the presence of gases in the molten metal. As is well-known, such gases are less soluble the lower the temperature, and if thrown out of solution immediately prior to solidification, they are trapped in the casting in the form of small bubbles.

"The more rapid the rate of solidification the less gas will be thrown out of solution; or, if thrown out, will be trapped in the form of minute bubbles. A slow rate of solidification, as in the case of the sand casting, allows of coalescence of gas bubbles, formation of larger cavities and consequently greater weakness. A third and most important reason for the comparative weakness of sand castings lies in the porosity of the metal due to cavities formed by minute bubbles of air and steam.

"It would appear, therefore, that the superiority of the chill casting is due more to soundness than to any marked difference in constitution. The chill casting does, however, exhibit a closer grain, the crystals being much smaller than the crystals in a sand-casting of similar composition.

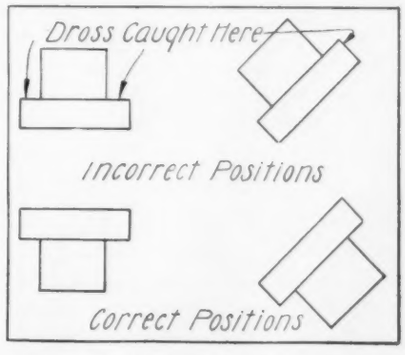


FIG. 3—INCORRECT AND CORRECT POSITIONS OF PERMANENT MOLDS

"The three materials which suggest themselves as suitable for chill molds are gray cast iron, steel and malleable cast iron. The former two have been used and have been found sat-

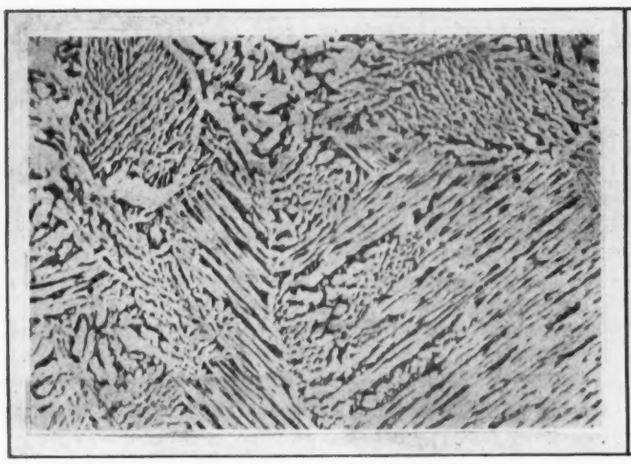


FIG. 4—MICROPHOTOGRAPH OF A CHILL CASTING MADE FROM ALLOY CH9, TABLE II
Magnification 100 diameters

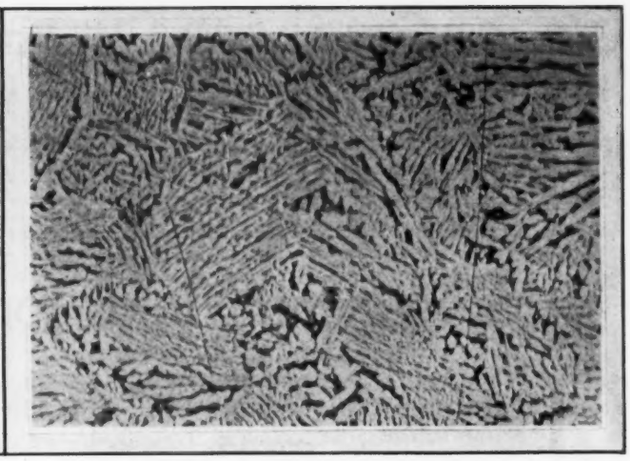


FIG. 5—MICROPHOTOGRAPH OF A CHILL CASTING MADE FROM ALLOY CH2, TABLE II
Magnification 100 diameters

isfactory. Cast iron molds are more easily produced than steel molds and should be made with a generous allowance for machining to the exact dimensions required for the production of a casting which also should have plenty machining allowance for the removal of surface defects. The thickness of the walls of the mold depends upon its size. For small castings the walls need not be more than 2 inches thick. Thin molds are more liable to fracture when roughly handled, and the thicker the mold the quicker the abstraction of heat from the casting. Steel molds may be thinner and it is possible in the case of single small molds to clamp together the split halves of a piece of round bar steel and machine-out the internal shape of the mold in the lathe.

Clamps Used

"Whether the parts of the mold form vertical or horizontal joints, strong clamps should be provided of a simple type which are adapted to rapid tightening and loosening. A form of clamp favored acts on the same principle as the ordinary foundry crucible tongs, the tightening being effected by forcing a small steel link over the handles. A simple ring of wrought iron with the free ends drilled to take a small bolt and butterfly nut is effective. A cast ring, drilled and tapped to take a small eye-bolt is also satisfactory and simply handled. For square or rectangular molds a rectangular ring fastened with an eye-bolt or wedges may be used. If the parts of the mold are hinged together, the hinges should work smoothly and easily. Dowel pins may be used to obtain correction of alignment of the parts and may serve also to hold them together when passed straight through the corresponding holes and held tightly by nuts or keys. The mold parts should be provided with suitable handles to facilitate handling when removing the casting; these either may be cast or screwed in.

"Strict attention should be paid to the venting of the joints so that there may be free egress for air from the mold. If there is insufficient provision for the escape of air, the casting either will be spongy or its surface spoilt by the presence of air pockets. By cutting thin, shallow grooves across the surfaces of the joints, these troubles may be obviated. One method of venting chill molds was described by H. G. Barrett at a meeting of the London branch of the British Foundrymen's Association, April 23, 1915.

Composition of the Molds

"The composition of the iron for cast iron molds is a problem of considerable importance. The iron should be tough and close-grained, and, it is needless to add, free from blowholes. Strength and toughness are important, as the molds have to withstand rough handling. W. J. May, in the *Mechanical World,* Aug. 20, 1915, gives some useful information on the making of permanent iron molds for castings, and recommends

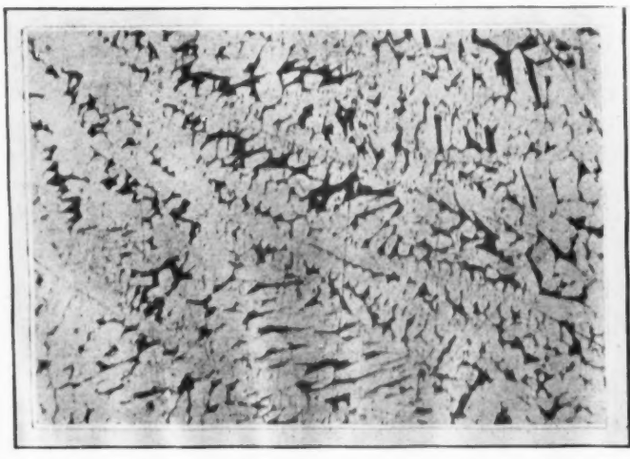


FIG. 6—MICROPHOTOGRAPH OF A CHILL CASTING, ALLOY CH9A, TABLE III
Magnification 100 diameters

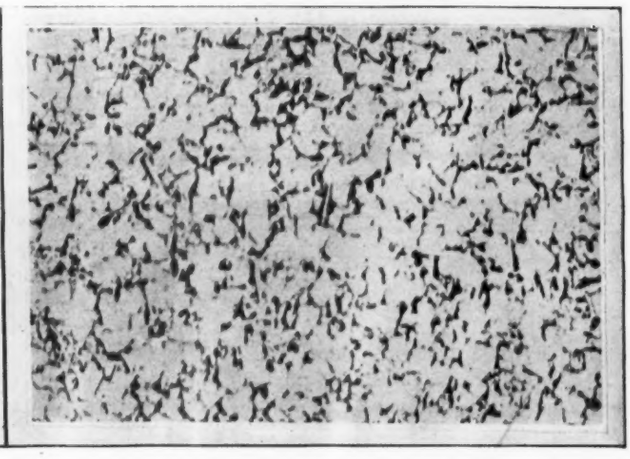


FIG. 7—MICROPHOTOGRAPH OF A CHILL CASTING MADE FROM ALLOY J2C, TABLE III
Magnification 100 diameters

their production with such a good finish that machining will be unnecessary. He cited the following composition of an iron successfully used for molds:

	Per Cent.
Combined carbon	0.84
Graphitic carbon	2.76
Silicon	2.02
Sulphur	0.07
Phosphorus	0.89
Manganese	0.29

"The high prosphorus content is justified by May on the ground that the fluidity which it confers enables molds of sharper outlines to be produced. He also states that an iron high in combined carbon would probably grow and become deformed under repeated heating.

Phosphorus Content

"From the point of view of the user a high phosphoric content is inadmissible. The phosphide eutectic has a very low fusing point and the repeated contact of molten copper alloys has an erosive effect which rapidly spoils the surface of the mold. Cast iron molds containing phosphorus and used for the casting of copper cylinders have deteriorated rapidly and caused much trouble in the extraction of the castings owing to the badly eroded surfaces causing sticking. The presence of phosphorus, moreover, increases brittleness and thus impairs the resistance of the mold to the effects of rough handling. A cast iron with low phosphorus content, therefore, is desired, for even if sharp outlines are not obtained, the surface can be machined and, thus prepared, allows of the production of castings cleaner and truer to size. It also must be remembered that not every molder can produce iron castings with highly finished surfaces.

"For the protection of the mold surface and to facilitate the extraction of the casting, a coating should be applied to its surface. Numerous dressings have been tried, such as seal oil, lard oil, linseed oil, Russian tallow, etc., mixed with charcoal or plumbago. Seal oil liberally charged with fine plumbago appears to be as satisfactory as anything. It should be warmed and liberally applied, well rubbed on to the mold surface and all excess removed before pouring. Considerably more disadvantage than advantage will accrue from leaving an excess of the oily dressing in the mold.

"In contact with the molten metal, partial distillation takes place with the production of gaseous hydrocarbons which are trapped in the casting before they can gain egress from the mold. Just sufficient coating is required to form a gaseous envelope between the casting and the mold to give a clean surface to the former, to facilitate its extraction and to protect the surface of the mold.

A Water Solution

"If carbonaceous coatings are considered undesirable, an emulsion of bone ash and water, applied with a brush to the warm surface of the mold, should prove satisfactory. The water is rapidly evaporated by the heat of the mold. A uniform and satisfactory coating may be applied by holding the mold surfaces over a smoky flame, that from burning rosin being effective, if troublesome. The warming of the mold prior to pouring is important owing to the blowing action of rust or moisture.

"The composition and arrangement of cores presents some difficulties. After using sand cores the use of tapered steel cores was resorted to and they were found to be more satisfactory. The careful alignment of sand cores in iron molds presents difficulties, whereas steel cores may be much more accurately fitted; they are permanent, thus effecting economy in labor, may be easily removed and leave a cleaner, smoother surface on the casting.

Gating

"The provision of a satisfactory gate for chill molds has introduced difficulties. Owing to the rapid chilling effect of the iron, no marked constriction of space at the junction of the head with the casting can be allowed, as the setting of the metal is likely to take place here before the casting has solidified. The solid neck thus formed prevents the remaining molten metal in the head from fulfilling its true function, namely, that of feeding the spaces in the casting caused by shrinkage. By carefully diminishing the rate of pouring as the mold fills, this difficulty may be partly overcome, but even with this precaution, a considerable amount of metal is required for the head when formed in the mold itself. It occurred to us that a very much smaller head would suffice if it could be kept molten until after the solidification of the casting. To effect this the gate was made in sand in a detachable ring placed on top of the mold and kept firmly in position while pouring. The lower thermal conductivity of the sand enabled a small head to do all the feeding. A small riser also was added for the purpose of securing free egress of gas and air from the mold.

"A cross-section of a permanent cast iron mold is shown in Fig. 1. The halves of the mold are indicated by *A*, *B* is the cast iron base and *C* is the steel ring for sand. Pegs *H* engage in slots in the steel ring *C*, forming a

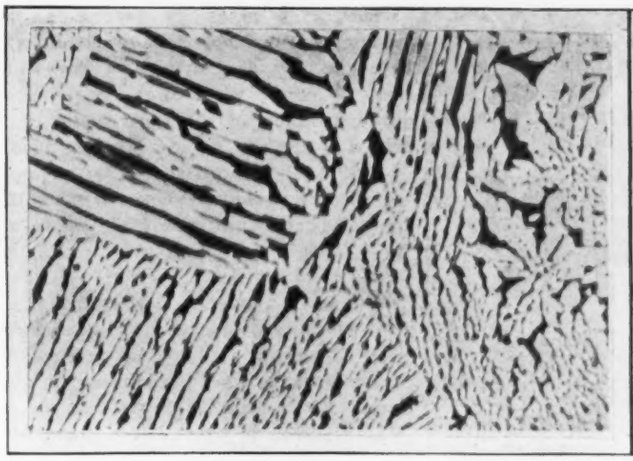


FIG. 8—MICROPHOTOGRAPH OF A CHILL CASTING MADE FROM ALLOY CH2, TABLE II
Magnification 200 diameters

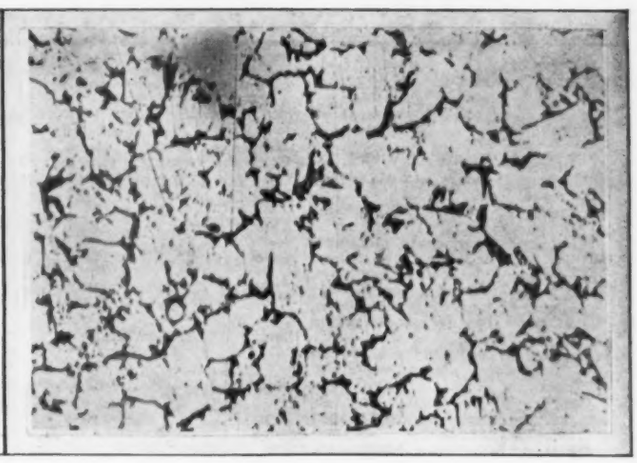


FIG. 9—MICROPHOTOGRAPH OF CHILL CASTING MADE FROM ALLOY J2C, TABLE III
Magnification 200 diameters

bayonet joint; the gate is shown at *D*, *EE* are the risers, and *FF* the handles. The small heads proved that the feeding was satisfactory. In one experiment the weight of the head represented only 8 per cent of the total weight of metal used.

"This method also has the advantage of securing a more effective elimination of dross, air and gas. Particles of dross on the surface of the rising metal in the mold are held in the solid skin which forms immediately when the metal touches the iron roof of the mold. When this roof is made of sand, the abstraction of heat is less rapid and opportunity is thus afforded for the particles of dross to be carried upward into the head. Gas and air also find an outlet through the interstices in the sand.

"The elimination of dross from the surfaces of the casting has proved to be the greatest difficulty in producing brass castings in chill molds. Various devices have been adopted to overcome this. The position of the mold has some bearing upon the problem. Taking, for instance, an article of cylindrical shape; if placed with its main axis in a vertical position, the ascending dross will have to change its direction from vertical to horizontal when the top of the mold is reached and the chances of its complete elimination are small.

"On the other hand, if placed in a position with the main axis at an angle of 45 degrees from the vertical, the horizontal surface of the molten metal will never strike a horizontal surface of the mold, and particles of dross will never have to choose the only alternative to imprisonment in the mold, namely, that of traversing a horizontal path towards the outlet. Similarly, a mold should be so made that any projecting portion of the casting is at the top and not at the bottom, in which case the overhanging portions of the mold encourage the imprisonment of dross. The incorrect and correct position of the mold are shown in Fig. 3.

Fluxes and Deoxidizers

"The best way to secure castings with smooth, clean surfaces is to prevent ingress of all dross and oxide to the mold. A suitable flux which will dissolve zinc oxide is useful, but zinc oxide is produced even in the stream of molten metal entering the mold, as also is aluminum oxide if aluminum is present. The addition of aluminum to copper-zinc alloys has the effects of checking oxidation of the zinc by reason of the formation of a tough, tenacious film of aluminum oxide on the surface of the molten metal. This film protects the underlying metal from oxidation and incidentally enables a clearer view of the contents of the crucible to be obtained, the formation of obscuring fumes of zinc oxide which are usually present being effectively obviated. No other deoxidizer which has been used has such a marked influence in this respect. Neither flux nor deoxidizer, however, will secure a clean stream of metal in practice, free from all dross, nor will the most careful skimming.

"To prove that dross was the cause of rough surfaces, the following experiment was made: A graphite crucible was pierced at the bottom with a ¼-inch hole and a ½-inch arc lamp carbon was used to plug up the hole and act as a stopper. This crucible was heated to redness and was placed in position over the gate of the mold. Molten metal was poured into the hot crucible and when it was reasonably certain that all the dross had risen to the surface, the stopper was removed and the clean metal from the bottom was allowed to teem into the mold. By this means castings were produced quite free from surface imperfections.

"To arrange for bottom-running in chill molds is extremely difficult owing to the danger of freezing the metal at any point of flow where there is a constriction of sectional area. To overcome this difficulty, it is proposed to arrange the gate and runners in sand, each runner supplying a chill mold. In this way the necessary head of metal is obtained for efficient feeding, a small riser to each chill mold allowing the escape of gas, air and dross. Bottom-running has this advantage, namely, that hot metal is continually coming up and pushes the floating dross in front of it. As solidification cannot commence until the mold is full, every facility is afforded for the escape of air and gases.

"In Fig. 2, *A*, *C*, *D* and *H* correspond to the lettering of Fig. 1, with the exception that *D* acts as a riser instead of a gate; *E* represents the main gate to four or more molds; *FF* are the runners formed in the sand bed *G* by the withdrawal, for a measured distance, of the square iron rods, *B*; *KK* are the clamps for the molds. This cross-section shows a method of casting a number of adapters together. The chill molds are arranged in a circle on the sand bed, *G*, and the completely enclosed space is filled with sand around a taper plug at *E*, which subsequently is withdrawn. The square rods, *B*, also are withdrawn latterly to a predetermined distance, which will leave the runner, *F*, clear. Metal is poured into the mold at *E*, follows along *F*, fills the mold and risers, *D*, which effect the necessary feeding. It is appreciated, of course, that this method could hardly be recommended as a commercial proposition, but represents the manner in which experiments in bottom-running were conducted due to the limited resources and time at our disposal. The results obtained show that all of the necessary feeding was supplied by the risers, *D*, thus indicating that the gate and runners not necessarily need be made in sand. The surface condition of the casting was good and the amount of caster's scrap was large. If there is no serious objection to producing so large an amount of scrap, it would seem that this method of bottom-running, arranging the gate, runners and casting in a chill with the riser in the sand to do the necessary feeding, offers the best prospect of producing clean castings. The position of the casting in Fig. 2 is the reverse of that in Fig. 1, since in bottom-running the dross and air are more perfectly eliminated and the position of

Table I

COMPARISON OF THE PHYSICAL PROPERTIES OF ALLOYS CAST IN SAND AND PERMANENT MOLDS.

Composition.	How cast.	Yield point, tons per square in.	Breaking stress, tons per square in.	Elongation, per cent.	Reference.
Copper, 85 per cent; aluminum, 5 per cent	Sand	4.3	18.1	75.0	Eighth report of the alloys research committee, 1907.
Copper, 85 per cent; aluminum, 5 per cent	Chill	7.1	18.1	60.5	
Copper, 90 per cent; aluminum 10 per cent	Sand	11.3	31.7	21.7	
Copper, 90 per cent; aluminum, 10 per cent	Chill	12.4	36.93	30.5	
Copper, 88 per cent; aluminum, 10 per cent; manganese, 2 per cent	Sand	13.2	34.44	24.0	Ninth report of the alloys research committee, 1910.
Copper, 88 per cent; aluminum, 10 per cent; manganese, 2 per cent	Chill	16.8	37.0	25.0	
Copper, 56 per cent; zinc, 41 per cent; iron, 1.5 per cent; tin, 0.9 per cent; aluminum, 0.45 per cent and manganese, 0.15 per cent	Sand	....	33.44	20.0	
The same alloy as given above.	Chill	....	38.4	25.0	

Table II

COMPOSITION, CASTING QUALITIES AND MECHANICAL PROPERTIES OF ALLOYS CAST IN PERMANENT MOLDS.

	Composition.									Mechanical properties.				
No.	Cop., per ct.	Zinc, per ct.	Man., per ct.	Iron, per ct.	Tin, per ct.	Alum., per ct.		Behavior in pouring.	Surface condition of casting.	Yield point tons per sq. inch.	Maximum break'g stress, tons per sq. inch.	Elongation, per ct.	Appearance of surface of stressed portion.	Appearance of fracture.
CH_1	58.64	38.9	0.926	0.212	....	0.162	Lead 0.107	Fluid	Smooth	17.25	30.4	22.5	Wavy, showing marked evidence of strain.	Deep yellow, crystalline.
CH_2	60.73	37.2	1.7	0.3	....	....	....	Rather pasty	Rough	11.7	25.4	40.0	Wavy.	Pale yellow, silky.
CH_3	62.21	34.7	2.5	0.5	....	....	Phosphorus 0.02	Rather pasty	Rough	9.8	20.8	32.0	Wavy.	Pale yellow, silky.
CH_6	60.84	34.66	3.43	0.28	....	....	Nickel 0.7	Rather pasty	Rough, spongy castings	9.0	21.4	38.0	Wavy.	Pale yellow, silky.
CH_7	60.0	33.0	3.25	0.75	2	1	....	Fluid	Smooth	13.0	20.6	6.0	Smooth.	Granular, small blow-holes present.
CH_8	56.91	37.31	2.48	0.2	1.67	0.26	Lead 1.16	Fluid	Smooth	25.3	31.8	7.5	Slightly wavy.	Deep yellow, crystalline.
CH_9	59.92	39.0	....	Trace	....	....	1	Fluid	Smooth	9.06	24.1	41.0	Wavy.	Full buff yellow, dull.

Of the above alloys, CH_1 is the nearest approach to "A" metal in mechanical properties. It is probable that between this composition and that of CH_8, an alloy could be found which would meet the requirements for "A" metal in the form of chill castings. Alloy CH_2 very nearly meets the requirements for "B" metal. Alloy CH_9 is an ordinary Muntz metal and easily meets the requirements for "G" metal.

Table III

COMPOSITION AND MECHANICAL PROPERTIES OF BRASS ALLOYS CAST IN PERMANENT MOLDS.

	Composition.						Casting qualities.		Mechanical properties.				
No.	Cop., per ct.	Zinc, per ct.	Mang., per ct.	Iron, per ct.	Alum., per ct.	Lead, per ct.	Behavior in pouring.	Surface condition of casting.	Yield point, tons per square inch.	Maximum breaking stress, tons per square inch.	Elongation, per cent.	Appearance of surface portion.	Appearance of fracture.
J2A	61.9	33.5	3.0	1.4	....	0.1	Pasty	Scabby	11.41	25.0	50	Smooth	Pale yellow, silky.
J2B	61.97	32.6	3.0	1.4	....	1.0	Pasty	Scabby	10.45	24.1	45	Smooth	Pale yellow, silky.
J2C	61.81	29.97	4.79	2.11	0.21	1.1	Fluid	Very smooth and glossy	12.4	24.8	42	Smooth	Pale yellow, silky.
CH9A	62.6	36.3	....	Trace	....	1.0	Fluid	Fairly smooth	7.59	22.6	29	Very wavy.	Full yellow, dull.

Of the alloys in the table, J2C satisfies the requirements of the Government specification for "B" metal. It behaved satisfactorily in casting and machining. The copper was purposely kept at approximately 62 per cent for the following reasons:

(1) Brass-casters often arrive at a higher copper content than required, namely, a mixture required to be 60-40 would often analyze 62-38 or even higher in copper.

(2) It seemed advisable, when aiming to produce an alloy having a minimum of 30 per cent elongation, to avoid those having an undue proportion of the Beta constituent.

The alloy CH9A is given for comparison, being an ordinary brass, similar in copper and lead contents, but free from aluminum, manganese and iron.

Table IV

COMPOSITION, CASTING QUALITIES AND MECHANICAL PROPERTIES OF ALLOYS CAST IN PERMANENT MOLDS.

	Composition.							Casting qualities		Mechanical properties.				
Copper, per cent.	Zinc, per cent.	Manganese, per cent.	Tin, per cent.	Aluminum, per cent.	Lead, per cent.	Phosphorus, per cent.	Behavior in pouring.	Surface condition of casting.	Yield point, tons per square inch.	Maximum stress, tons per square inch.	Elongation, per cent.	Appearance of stressed portion.	Appearance of structure.
88.0	2	....	10	....	....	trace	Fluid	Smooth	11.1	18.35	10.5	Slightly wavy	Dull, granular
90.0	....	5	5	....	....	0.15	Pasty	Rough and scabby	11.5	15.6	11.0	Very wavy	Dull, granular
[1]85.35	10.09	....	4.48	....	0.08	....	Fluid	Very smooth	9.6	21.8	39.0	Wavy	Dull, granular

[1] This alloy was sent to the Royal Arsenal, Woolwich, and was cast in a chill mold, using a sand core. The figures given were obtained in the Royal Laboratory.

Table V

TESTS MADE AT THE ROYAL ARSENAL, WOOLWICH, OF CHILL CASTINGS. ALLOYS FOR FUSES.

	Composition by analysis.							Tensile tests.			
Mark	Copper, per cent.	Lead, per cent.	Iron, per cent.	Aluminum, per cent.	Manganese, per cent.	Tin, per cent.	Zinc, per cent.	Yield point, tons per square inch.	Breaking stress, tons per square inch.	Elongation, per cent.	Remarks.
1	59.7	1.38	0.13	0.3	1.4	....	diff.	8.5	28.5	28.0	Iron and Manganese introduced with the copper as ferro-manganese; aluminum, lead and commercial spelter finally.
5	59.1	0.96	0.04	0.35	Nil	....	diff.	9.0	27.0	38.0	Commercial spelter; aluminum and lead added last.
6	60.6	0.94	[1]2.0	....	Nil	....	diff.	9.0	25.0	41.0	Iron bar in small pieces melted with the copper; spelter and lead added last.
15	59.2	2.12	Nil	....	[1]2.0	....	diff.	9.0	24.5	36.0	Copper and cupro-manganese melted together; lead and spelter added last.
18	60.93	0.89	0.08	1.01	2.13	....	diff.	12.0	30.5	32.5	
20	66.12	0.9	0.03	3.46	Nil	....	diff.	12.0	31.5	35.0	

All these alloys machine and screw well.

[1] The compositions of bars 6 and 15 have not been fully verified. The figures marked (1) give the percentage aimed at; the others are actual composition.

Lead has been intentionally added in order to represent as far as possible the worst conditions which could be obtained by using commercial spelter high in lead.

the casting can have no material influence upon the cleanness of the surface, especially if means be provided for trapping dross in the runner.

"The problem which first confronted us was how to produce an alloy in the form of a casting which would give as good results in the manufacture of fuses and meet the same stringent specifications for mechanical tests as some of the highest qualities of rolled brass bar. The British government specification for *A* metal, to which reference is made, follows:

Yield point	20 tons per square inch
Maximum stress	30 tons per square inch
Elongation	20 per cent

"In order that risks of premature explosion of shells may be avoided, the presence of lead was prohibited except in very minute proportions, namely, 0.01 per cent. Although this was altered afterward to 0.10 per cent, it is obvious that there was no hope of supplying the big demand created in the early days of 1915 from the existing stocks of lead-free brass and zinc. It was necessary to fall back upon the commoner grades of metal and to suitably and effectively coat the castings with a metal or substance which contained no such injurious element as lead. It is the ready formation of lead picrate which, owing to its explosive action, has to be circumvented at all costs.

Lead in Brass

"The presence of lead in brass, however, has two other important effects, one good and the other bad, namely, the improvement of the machining properties and the impairment of the mechanical properties.

"To emphasize the superiority in mechanical properties of chill castings over sand castings, comparison of physical results of the same alloys made by these processes are given in Table I.

"After a brief survey of the common metals available, it was decided that the copper-zinc alloys offered the most promising field for research. It was realized that no alloy of copper and zinc, without the addition of some other metal, could give the desired results. Attention, therefore, was given to the so-called manganese bronzes which are copper-zinc alloys, to which other metals such as manganese, iron, tin and aluminum are added in various proportions. The following composition is given by Gillett:

	Per Cent.
Copper	56.0
Zinc	41.0
Iron	1.5
Tin	0.9
Aluminum	0.45
Manganese	0.15

"The results of mechanical tests on a chill cast alloy of this composition are given as follows: Maximum breaking stress, 38.4 tons per square inch, elongation, 18.0 per cent minimum and 25.0 per cent maximum. An alloy of this type, modified in composition to insure a percentage of elongation of over 20 per cent, was made and tested in the form of a ¾-inch square chill cast bar. The composition of this alloy, by analysis, was as follows:

	Per Cent.
Copper	58.64
Zinc	38.9
Tin	1.053
Manganese	0.926
Aluminum	0.162
Lead	0.107
Iron	0.212

Results of Mechanical Tests

Yield point	17.25 tons per square inch
Maximum	30.4 tons per square inch
Elongation	22.5 per cent on 2 inches

"It will be noted from the test figures that this, the first attempt, failed only in yield point and by a very little, to meet the specification for *A* metal. The following composition[1] has been recommended for shrapnel sockets to be made in chill molds:

	Per Cent.
Copper	56.0
Manganese-copper	2.0
Zinc	41.0
Tin	0.5
Aluminum	0.5

"In Table II are given the approximate compositions and test results of other alloys of an exploratory character.

"The results obtained from the alloys in Table II, suggested that by further stiffening, the yield point and maximum stress might be considerably raised, without lowering the elongation to 20 per cent.

"Knowing the limitations of tin and desiring to avoid so expensive an ingredient, and knowing also the detrimental action of large additions of aluminum on the surface condition of chill castings, it was decided to omit the former and add only so much of the latter as was required to give fluidity. This small quantity of aluminum has a remarkable influence on the fluidity and surface of these alloys. The desired increase in strength was hoped for from larger additions of manganese and iron.

"An important modification of the specification was introduced at this point, *B* metal having been substituted for *A* metal, and the lead restriction had been eased. The specification for *B* metal follows:

Yield point	12 tons per square inch
Maximum stress	20 tons per square inch
Elongation	30 per cent on 2 inches

"In Table II are given the results of experiments made to produce a chill casting of *B* quality.

"While much work remains to be done to ascertain the individual influence of each metal, it nevertheless seems fairly certain that manganese has only a mild influence and that of iron is more intense. These two metals together give the brass a paler hue, but also consolidate the structure giving fineness of grain and increased toughness. The microphotographs, Figs. 4 to 9, show how the crystalline structure is altered, a much finer structure resulting from the addition of manganese.

"Fig. 4 shows the alloy CH9, Table II, containing copper, 59.92 per cent; zinc, 39 per cent, and lead, 1 per cent. It will be noted that the structure is coarsely crystalline, as compared with alloy CH2, Fig. 5.

"The microphotograph of the alloy CH2, Table II, cast in a permanent mold, is shown in Fig. 5. It contained copper, 60.7 per cent; zinc, 37.2 per cent; manganese, 1.7 per cent and iron, 0.3 per cent. It will be noted that the structure is not as coarsely crystalline as Fig. 4.

"The microphotograph of alloy CH9A, Table III, cast in a permanent mold, is illustrated in Fig. 6. This contained copper, 52.6 per cent; zinc, 36.3 per cent, and lead, 1 per cent. This was coarsely crystalline, as compared with a structure of the alloy shown in Fig. 7.

Fine Structure

"The microphotograph of alloy J2C, Table III, cast in a permanent mold, is shown in Fig. 7. It contained copper, 61.8 per cent; zinc, 29.9 per cent; manganese, 4.8 per cent; iron, 2.1 per cent; aluminum, 0.2 per cent, and lead, 1.1 per cent. Its crystalline structure is much finer than that of Fig. 6.

"Fig. 8 is a microphotograph of the same alloy shown in Fig. 5, but with a magnification of 200 diameters, as compared with 100 diameters in Fig. 5. Fig. 9 is a microphotograph of the same alloy shown in Fig. 7 with a magnification of 200 diameters, as compared with 100 diameters for Fig. 9.

"The behavior of these alloys under stress is quite different from that of the pure copper-zinc alloy, which shows the external surface flow lines usually associated with cast brasses. The presence of 1 per cent of lead results in improved machining properties and the cost of the alloy is reduced. The risks which would result from its contact with picric acid are obviated by other means, namely, tinning or nickel-plating.

"The small addition of aluminum, while adding to the strength, produces an extraordinary improvement in casting qualities. Without aluminum the alloy is pasty and runs sluggishly."

[1] *The Foundry*, July, 1915, page 279.

Permanent Graphite Molds for Metals and Alloys

The Development of Artificial Graphite Molds Represents a Big Forward Stride in Brass Foundry Work—Temporary Molds and Feeders

CHARLES VICKERS, Niagara Falls, N. Y., well-known expert in brass foundry practice, has been granted a patent on a permanent mold made of graphite for making non-ferrous metal castings, which he has assigned to the Titanium Alloy Mfg. Co., of Niagara Falls, N. Y., with which he is affiliated. The mold is made of graphitized carbon used preferably in the form known as artificial graphite. This is exceedingly refractory and is resistant to high temperatures and, therefore, the mold can be used repeatedly for making castings. This substance is one of the most rapid heat conductors known and consequently has a rapid chilling effect on the metal, preventing liquation attributable to slow cooling of the metal in the mold.

Liquation of Constituents

It is well-known that in the production of castings from alloy comprising two metals, the one of which is of a high and the other of a relatively low melting point, a separation throughout the casting into alloys of different composition takes place. Such alloys having the highest fusing point solidify first and the entire mass becomes only gradually solid by further cooling. Therefore, when freezing or solidification commences, an alloy rich in the metal of the higher melting point and poor in the metal of the lower melting point will first separate as a solid and this is followed by the solidification of various other alloys containing progressively less of the former metal and more of the latter, the last alloy to separate and to solidify being proportionately very rich in the metal of the lower melting point and correspondingly poor in the other. The resulting casting thus lacks homogeniety and consequently is weaker in spots than it should be. The graphite mold overcomes this liquation and causes the rapid cooling of the metal.

It also is pointed out that graphitized carbon is capable of having its heat-conductive property modified and adjusted to meet the requirements of different metals or even different parts of the same casting. For example, when meeting special requirements, Mr. Vickers has constructed these permanent molds from graphite, either artificial or natural, with a binder such as tar or pitch, which then was baked in a furnace similar to the procedure in ordinary carbon manufacture. When a heat conductivity was imparted to the mold too great for successful use in certain forms of castings by this process, he adjusted the heat conductivity to that required by adding to the constituent mixture a certain amount of amorphous carbon, determined to be sufficient to reduce the heat conductivity of the mold. He also states that he can form his permanent molds wholly out of the amorphous carbon and then graphitize them in an electric furnace. Here again he is able to adjust their heat conductivity as required. By correspondingly adjusting the temperature of the furnace, he is able to regulate the extent of the graphitization of the amorphous carbon and thereby correspondingly control the heat conductivity of the resulting mold. The heat conducting properties of the permanent mold can be adjusted locally by varying its thickness at different points or zones, corresponding to the thicker and thinner parts of the castings and by this means he insures more rapid heat withdrawal from the thicker parts and less rapid from the thinner parts of the mold, thus insuring substantial uniformity of heat-withdrawal from all parts of the casting at the same rate and an equal amount during a given time.

Temporary Molds

In cases where a permanent mold is not required, a temporary mold can be made from a form of graphite obtained by the decomposition of silicon carbide or other similar carbides, since this form possesses plastic, coherent properties when subjected to pressure. Also, the temporary mold may be made from a mixture of graphitized carbon and molder's sand, regulating the proportions so as to impart to the mold the degree of heat conductivity best suited to the particular kind of casting desired. For the purpose of demonstrating the influence of the graphitized carbon permanent mold on the physical properties of non-ferrous metal castings, Mr. Vickers made a series of tests with an alloy containing aluminum, 92 per cent and copper, 8 per cent. From this alloy he made castings from the same heat in four different molds made respectively of sand, amorphous carbon, iron and graphitized carbon. The results of these tests follow:

Casting.	Ultimate strength, pounds.	Per cent elongation.	Per cent reduction.
In sand mold.....	12,300	1.0	0.7
In amorphous carbon mold	17,700	1.8	1.3
In iron mold.....	25,500	3.5	4.1
In graphitized carbon mold	26,300	3.8	4.4

The four substances thus employed are superior to each other in heat conductivity as molds in the order named, that of sand being the least and that of graphitized carbon the greatest. Similar tests with other alloys gave analogous results.

Graphite and Sand Molds

Tests also were made on temporary molds consisting of a mixture of sand with graphite as compared with that of sand molds, the alloy used having consisted of 92 per cent aluminum and 8 per cent copper. The ultimate strength of the castings made in the sand mold was 21,650 pounds and that from the graphite and sand molds 26,780 pounds.

In view of the rapid chilling properties of the graphitized carbon mold, it is necessary to employ risers or feeders of ample size made of a lower heat conducting substance or mixture than the mold itself. The riser is made of molder's sand and by its use the casting is continuously fed until solidification takes place. In casting in sand molds, for example, for some alloys it has been found necessary to have the riser fully as bulky as the casting and in making some alloys, such as aluminum bronze, the ratio of bulk of riser to that of the casting has been as high as 1½ to 1. However, with the use of the graphitized carbon permanent mold the relative proportions of riser to casting are materially reduced and in usual practice it does not exceed one-fourth of the bulk of the casting. This permanent mold has been found advantageous in casting copper, nickel, lead, zinc, aluminum and many alloys comprising some of these metals, such as German silver, brass, bronze, gun metal and the white metals, and it also has proved useful in casting ferrous metals and their alloys.

PROBLEMS OF THE BRASS FOUNDER

What To Do and How To Do It

A Substitute for Platinum

Since the beginning of the war platinum has become exceedingly scarce and it has advanced rapidly in price. We have been informed that a substitute for platinum is now available and if possible, we would like to have you give us some information on this subject.

An alloy for use in contact and spark devices intended to replace platinum has been patented by Paul R. Heyl, of New Rochelle, N. Y., and has been assigned to the Commercial Research Co., New York City. This alloy consists of silver and palladium in varying proportions, according to the conditions under which it is to be used. An alloy of silver containing 2 per cent palladium has been found to give good results under many conditions. When the contacts or spark points are exposed to sulphur compounds, 5 per cent or more of palladium should be used. Additions of palladium to silver raise the melting point and lower the thermal conductivity. It has been found that owing to the high thermal conductivity of silver, the heat from the spark will be conducted away fast enough to prevent melting the silver.

Effect of Phosphorus on Bronze

In a mixture consisting of copper, 84 per cent; tin, 6.5 per cent; lead, 7 per cent and zinc, 2 per cent, how much phosphor-copper should be used to obtain sound castings? If the zinc were omitted entirely, would it be advisable to increase the percentage of phosphor-copper? Does the introduction of phosphor-copper have a tendency to harden the metal and does it have any effect other than to absorb oxygen? We would like to know whether an alloy made by the foregoing formula, using scrap trolley wire and heavy plate copper scrap is harder than if only electrolytic copper were used. We have been making castings using scrap in preference to electrolytic copper, but our finishing department claims that they are harder to machine than those made from new copper.

For deoxidizing a mixture of copper, 84 per cent; tin, 6.5 per cent; lead, 7 per cent and zinc, 2 per cent, 1.5 per cent of 0.5 per cent phosphor-copper will be sufficient. This introduces 0.75 per cent of phosphorus which is insufficient to have any appreciable hardening effect on the alloy. Phosphorus has a distinctly hardening effect on the bronzes to which it is applied as it forms a phosphide which is dissolved in the alloy as a definite compound which is hard and brittle. This occurs in a more marked degree when the percentage of phosphorus reaches 1 per cent. The alloy given should be no harder when made from scrap than if electrolytic copper were used exclusively. The point, however, can be easily determined by hardness tests. If the scrap copper is free from iron, no more trouble should be experienced in machining the castings than when new metals are used.

Casting Bronze on Iron

Can a brass sleeve be cast successfully on a 9½-inch propeller shaft? I tried this, but was unsuccessful. If it can be done, kindly let me have a mixture for this work and what method should be pursued in casting such a sleeve? I have successfully cast sleeves on a 9-inch pipe and have experienced no trouble.

No particular difficulty should be experienced in casting bronze sleeves onto solid shafts provided the shaft is heated before being placed in the mold and the bronze is poured immediately after the insertion of the shaft. Heating the shaft expands it and removes the moisture from the surface, which is necessary to prevent the sleeve from cracking and blowing. It always is advisable, in casting bronze over iron, to flow-off the bronze, since this procedure heats the shaft and has a tendency to fill up any blow-holes that may be formed when the bronze first strikes the comparatively cold steel. The latter should be absolutely clean, free from all rust and scale or other oxide and to insure this it should be rubbed with fine emery cloth before it is set in the mold.

A suitable mixture for this work follows:

Copper, 88 per cent; tin, 10 per cent and zinc, 2 per cent.

The mold should be faced with a dry sand mixture to withstand the heat radiated from the hot shaft and the prints in which the roll is set must be reinforced to carry the weight of the shaft without crushing.

Trolley Wheel Mixtures

In the March number of THE FOUNDRY *was published a mixture for trolley wheels, but in referring to back numbers, namely the issue of December,* 1914, *a mixture is given as follows: Copper, 92 pounds; tin, 6 pounds and phosphor-tin, 2 pounds. The mixture recently published contains copper, 92 pounds; phosphor-copper, 2 pounds and tin, 6 pounds. The latter mixture seems to me to contain too much copper and I would like to know which mixture should be tried?*

Both of the trolley wheel mixtures given are good, but the one containing the greatest amount of tin is the most expensive and also the hardest and should give better wear under equal conditions. Some street railroads prefer a soft trolley wheel to a hard one, as they claim that it is easier to replace the wheels than the overhead copper wire. Since this procedure, however, is always open to question, it might be advisable to obtain the views of the customer on this subject before making the mixture. Trolley wheels can be made of an 88-10-2 mixture if greater hardness is required and sometimes they are made of scrap exclusively. However, the mixture containing 6 per cent tin is most generally used.

Removing Adhering Core Sand

In making small brass castings we find that the sand adheres to the cored sections and we would like to know how this can be prevented. The cores are made from river sand, linseed oil being used as a binder. We have tried oil and silica sand, but the results have been the same. Would an acid dip of some kind remove the sand from the castings?

The trouble is due to the fact that the castings are too thin to burn the oil from the sand and, therefore, the cores remain hard and only can be removed with a great deal of difficulty. One remedy would be to make the cores softer by using less oil as a binder. This can be accomplished easily by mixing one quart of linseed oil in two quarts of boiling water, which should be stirred thoroughly and used in the proportion of one part of the solution to 28 quarts of dry, sharp sand. If the cores still

are too hard for this particular work, reduce the amount of binder or eliminate the use of linseed oil and employ the following mixture: Starch, 4 ounces; powdered glue, ½ ounce and water, 1 pint. Cook the starch and glue together, bringing it slowly to the boiling point and stir it constantly to prevent it from burning to the bottom of the vessel. When it reaches the boiling point a jelly will form which should be mixed with all of the dry, sharp sand that it will wet to a proper molding consistency. If the foregoing proportions are used, it will wet five quarts of dry silica sand. If the cores are to be handled green, it will be necessary to mix molding sand with the silica in order to make strong cores and the amount of molding sand to be added must be governed entirely by the amount of handling the cores are expected to receive. The less molding sand used the more easily the cores can be removed from the castings. This mixture will leave the castings easily and the cores should be merely dried, not baked. The use of an acid dip for removing the sand from these castings would prove to be expensive and also unsatisfactory.

Screen Plates for Paper Mills

We are making bronze castings, 12 x 48 inches and ½ inch thick, which weigh about 90 pounds each. These plates are milled and fine slots are cut into them. In use they come in direct contact with the acids employed in making sulphite pulp. We have been conducting experiments with a view of obtaining material which would give maximum wear by resisting the acids to the highest degree. At the present time our mixture consists of copper, 72.5 per cent; tin, 10 per cent; lead, 15 per cent and phosphor-copper, 2.5 per cent. After the castings are machined they show considerable porosity. We would like to know how this can be overcome and whether it is due to the temperature at which the metal is poured or whether other conditions cause it. Can you give us a formula for acid-resisting bronze which will give equally good results and produce sound castings? Is a pyrometer in use today which is giving satisfactory results? We have experimented with several, but they have not proved practical.

The following alloy is used extensively for making screen plates for paper mills: Copper, 84 per cent; tin, 7.5 per cent; lead, 7 per cent and zinc, 1.5 per cent. However, in some districts, scrap is used exclusively. The brass should be free cutting to permit of machining the slots easily. With reference to your mixture, we are of the opinion that it contains too much phosphorus, that it would be liable to liquate and that a compound of tin and phosphorus with some lead and copper would ooze from the pouring heads as they solidify, causing defects in the plate. We suggest that the phosphor-copper be reduced to 0.50 per cent and the phosphorus then would be sufficient to serve as a deoxidizer only. Melt the copper under a good cover of charcoal and a small amount of salt and when molten, stir in the phosphor-copper, following with the tin and lead. This should give clean metal that will run sound.

Melting Bronze in a Cupola

We would like to know how to cast a bronze bearing inside of a gray iron shaft opening and how to eliminate blow-holes in bronze bearings cast in this way. Also, we would like to have some advice on melting bronze in a cupola and for casting a piece weighing 1,400 pounds. How much coke should be charged and how many charges of metal and coke should be made?

If the bronze is to be cast in contact with the iron, it will be necessary to heat the iron until it is nearly a dull red. No difficulty should be experienced from blow-holes if the iron is hot and absolutely free from rust. If the iron casting is too large to heat readily, it will be advisable to flow-off some of the brass. A cupola is a poor medium in which to melt brass or bronze because copper absorbs sulphur from the coke and oxygen from the blast and these two elements unite to form sulphur dioxide, a gas which is liable to be retained by the copper, resulting in the production of spongy castings. However, if the metal must be melted in the cupola, proceed in the same manner as when melting iron, although the blast should be slightly reduced and anthracite coal should be substituted for coke, if good results are to be obtained. As a deoxidizer, use 15 per cent of phosphor-copper in the proportion of 0.5 per cent. Place the phosphor-copper in the bottom of the ladle onto which the bronze is to be tapped.

Recovering Metal From Drosses

What is the best flux to use for recovering the metal from lead, type metal, tin and solder drosses? We operate a large, oil-fired reverberatory furnace.

The kind of flux used in refining white metals will depend largely upon the nature of the impurities that are to be removed. The fluxes most commonly employed are sal-ammoniac, rosin and sulphur in kettle refining, and sodium sulphide, iron in various forms, fluorspar, clay, carbon and oxidized metals in furnace refining. In recovering lead by the kettle process, the zinc is removed by agitating the bath with sulphur and by stirring the metal thoroughly. This brings to the surface a pasty dross which holds considerable lead, and to remove this lead, rosin is used, which is thrown onto the surface of the bath and stirred into the pasty dross. The lead from the dross then enters the bath, which then is recovered, and the zinc sulphide, which remains on the surface of the metal, can be skimmed off in the form of a powder. Copper and aluminum also are impurities of lead and can be removed by adding zinc to the bath, which takes up the copper or aluminum and then is removed by using sulphur, the same as previously described. Sal-ammoniac is employed in the removal of copper and iron, while arsenic is removed by treating the metal with caustic soda. Antimony is removed at comparatively high temperatures by the employment of litharge as a flux in leady metals, the resulting dross being antimonial litharge and the metal soft lead. Zinc solder can be cleaned by blowing steam through the bath and by the addition of sulphur. Sulphur is an important agent in refining operations, being always played against the oxygen until the sulphur combines with some comparatively worthless metal recovered in the slag, and the more valuable metals are left in the liquid state in a more or less oxidized condition. The oxygen then is removed by hydrogen, which is introduced by poling operations.

Electro-Platers' Convention

The annual meeting of the American Electro-Platers' Society, which was to have been held at Toronto, Ont., this year, but which will not be held at that place on account of the war, now is scheduled for Cleveland with headquarters at the Hotel Statler, July 6, 7 and 8. A large number of interesting papers on plating and non-ferrous metallurgy will be presented. The Cleveland branch of this society is arranging a suitable entertainment program, which is in charge of Charles Werft, 1341 East 112th street, Cleveland.

The Audubon Wire Cloth Co., Audubon, N. J., is having plans prepared for a new building, 60 x 90 feet, of reinforced concrete construction, which will be used as a wire weaving department. Looms now are being built for installation in this plant. The output of these works will be increased about 30 per cent by this addition.

Panoramic view of the plant of the Sivyer Steel Casting Company

Application of the Converter and Electric F

At the Plant of the Sivyer Steel Casting Co., Milwaukee, an Electric S the Surplus Scrap Which Heretofore Has Been Sold—Features of t

A NOVEL and interesting application of the electric furnace to dispose of excess side-blow converter steel scrap has been made at the plant of the Sivyer Steel Casting Co., Milwaukee. Since neither sulphur nor phosphorus is reduced in the converter, the metal charged for conversion into steel must be of a definite composition within certain limits and the percentages of both sulphur and phosphorus should be as low as possible and under 0.05 per cent in the castings. It is the practice in all converter plants to charge into the cupola a certain percentage of shop scrap, but since the castings made in all of these foundries are light and the gates, sprues and heads constitute 50 per cent or more of the melt, an excess amount of scrap is produced which cannot be consumed and is sold in the open market. The use of too high a percentage of this scrap in the cupola mixtures, with the added increase of sulphur from the coke, would raise the sulphur content above the prescribed sulphur limits for converter steel.

Although the Sivyer Steel Casting Co. operates only one 1-ton Tropenas converter, its daily production of shop scrap, in the form of gates, sprues and heads is unusually large, due to the fact that from 22 to 23 blows are made from about 7:30 a. m. to 5:30 p. m. This practice far surpasses that of any other converter shop in this

FIG. 1—GENERAL VIEW OF THE SIVYER STEEL CASTING CO.'S FOUNDRY, SHOWING THE ELECTRIC FURNACE AND THE CONVERTER

waukee, equipped to manufacture converter and electric steel castings

Furnace in the Production of Steel Castings

Steel Furnace Has Been Installed for the Purpose of Utilizing the Plant With Details of the Well-Arranged Cleaning Room

country and it is doubtful if it is equalled abroad. Heretofore the surplus scrap which could not be charged into the cupola has been sold, but since it is far more economical to use this material it was decided to install an electric furnace for the purpose of melting and refining it. The furnace is of the basic type, built by the Snyder Electric Furnace Co., Chicago, and has a capacity of 3,000 pounds per heat. It was first placed in operation in April, cold stock being used. All of the surplus shop scrap now is being utilized in this way and the combination of the electric furnace and the converter, considering the economies that can be effected, has bright promises of further application. As shown in the general view of the foundry, Fig. 1, and in the plan of the plant, Fig. 15, the electric furnace is located in the same side of the shop as the converter and the cupolas, all of the melting and steel-making being confined to one end of the foundry by this arrangement. A near view of the Snyder electric furnace is shown in Fig. 7. To remove the transformers and other electrical equipment for the electric furnace from the ground level and away from the dust and smoke of the foundry, the transformer house has been built on the roof to which access is had through an opening in the floor and by means of a ladder from the foundry. With this opening closed, the transformer room can be kept clean and it is well ventilated through windows in the sides and large ventilators in the roof.

FIG. 2—GENERAL VIEW OF THE SIVYER STEEL CASTING CO.'S ORDERLY AND WELL-ARRANGED CLEANING DEPARTMENT

FIG. 3—A VIEW OF THE CLEANING ROOM LOOKING TOWARD THE SHIPPING FLOOR IN THE REAR

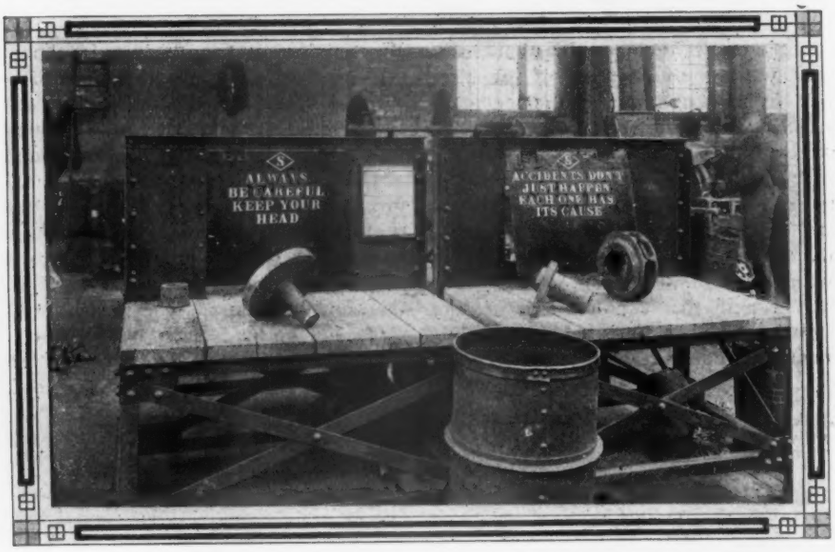


FIG. 4—TWO OF THE CHIPPERS' BENCHES, SHOWING THE INSPECTORS' SIDE AND SAFETY FIRST SIGNS

FIG. 5—UNDERGROUND EXHAUST FOR THE GRINDING STANDS, WHICH REMOVES ALL OVERHEAD PIPING

Organized in 1909 to engage in the production of crucible steel castings, the Sivyer Steel Casting Co. has enjoyed a phenomenal growth. The first plant was located in one of the buildings of the Northwestern Malleable Iron Co., Milwaukee, but in 1910 the growth of the business made necessary the erection of a small plant on the present site. In 1912 a 1-ton Tropenas converter was installed and two years later the elimination of the crucible furnaces was commenced, the entire output subsequently consisting of converter cast steel. The recent addition of the electric furnace practically doubles the capacity of the plant and to keep pace with the increased steel production numerous additions and extensions have been made.

Arrangement of the Plant

As shown in the ground plan of the plant, Fig. 15, the foundry is 90 x 375 feet and paralleling practically one-half of the length of the shop are the concrete raw material bins, 190 feet long. At right angle to the foundry is the recently completed cleaning room, 75 x 153 feet, and in another building, in which the crucible furnaces formerly were located, are the core room, 50 x 70 feet; the carpenter shop, 50 x 70 feet, and the store room, 25 x 70 feet. The pattern vault is located in a detached, one-story structure, approximately 50 feet square.

As illustrated in the ground plan, Fig. 15, the cupola in which the iron is melted is located adjacent to the converter, reducing to the minimum the distance the molten iron must be carried for charging into the steel-making vessel. In the same end of the shop, and at a distance of about 45 feet from the converter, is the Snyder electric furnace. The two sand mixers are directly opposite and adjacent to the sand bins, thereby minimizing the hauling distance of the sand to the mixers. One of these mixers, recently installed, is of the Simpson intensive type, and was furnished by the National Engineering Co., Chicago. The cupola is lined to a diameter of 38 inches and is operated continuously to provide metal for the converter. Two oil-fired ladle heaters are provided, one for heating small hand ladles and the other for bull ladles. As far as possible, the molds are poured directly in front of the converter and electric furnace. All of the snap-flask work is conveyed to this end of the shop for casting, although the larger molds are poured in the sections of the shop in which they are made. This scheme permits of the employment of

a separate pouring and shake-out gang and, furthermore, confines to one part of the plant the smoke incident to pouring-off and the dust and dirt arising from shaking-out. It also is conducive to an orderly, well-kept foundry, which is the first essential for good work. The molding and casting department is commanded by two 5-ton, Pawling & Harnischfeger overhead traveling cranes.

The Casting Floor

The casting floor of the foundry is in the immediate foreground of Fig. 1, and several floors of snap flasks represent the work of the operators of the power squeezers, which parallel the wall directly opposite the electric furnace. Snap flask molds from the other squeezer floors on the opposite side of the shop and adjacent to the jolt machine floors, instead of being placed on the floor for pouring off, are set on long steel channels, and these, when filled, are conveyed by crane to the casting floor. One of these steel channels containing eight molds, lifted by a crane, is illustrated in Fig. 12. Special hooks engaging pins on the channel are looped by chains from the crane. At *A*, in the foreground of Fig. 12, is one of the channels with only one mold in position. Attention also is directed to the steel bands on these molds which eliminate the use of slip jackets. These bands are placed inside of the snap flask when the mold is being made and when the flask is removed remain in position. The use of these steel bands eliminates all danger of a crush which occurs occasionally when slip jackets are forced down upon a mold.

Casting Grid

An interesting piece of home-made equipment is the casting grid, shown in Fig. 11. After shaking-out the castings, they are piled on this grid for delivery to the cleaning department, the surplus sand falling through the grid openings. Four eyes are cast on the grid for the insertion of the crane hooks. Lip-pour ladles only are used, bottom-pouring not being resorted to even for large work. The molding machine equipment consists of four Tabor power squeezers, eight hand squeezers of the Farwell type, eight Tabor and Herman jolt-ramming machines and one Pridmore stripping plate machine. Air is furnished by two electrically-driven and controlled automatic air compressors, built by the Chicago Pneumatic Tool Co., located in rooms partitioned off in either end of the foundry, as shown in Fig. 15. Locker rooms are located on the floors above the com-

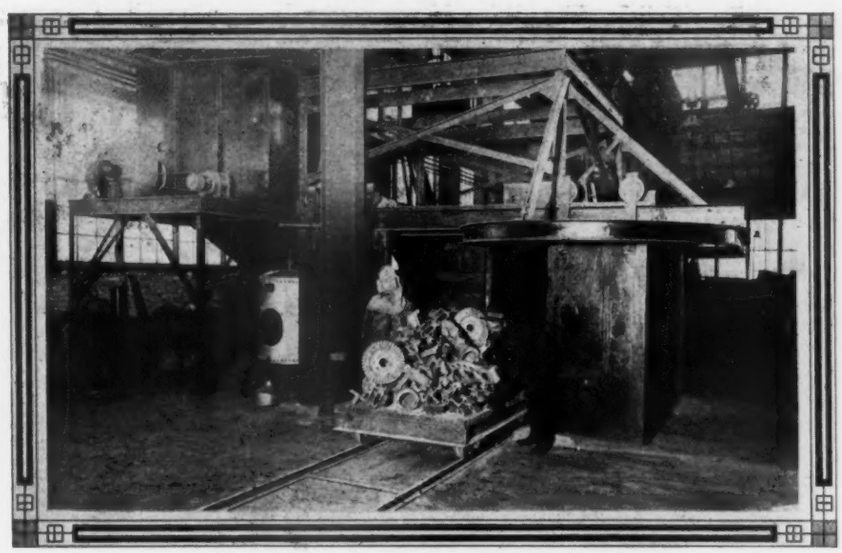


FIG. 6—SAND BLAST ROOM, SHOWING THE CAR ON WHICH THE CASTINGS ARE CLEANED

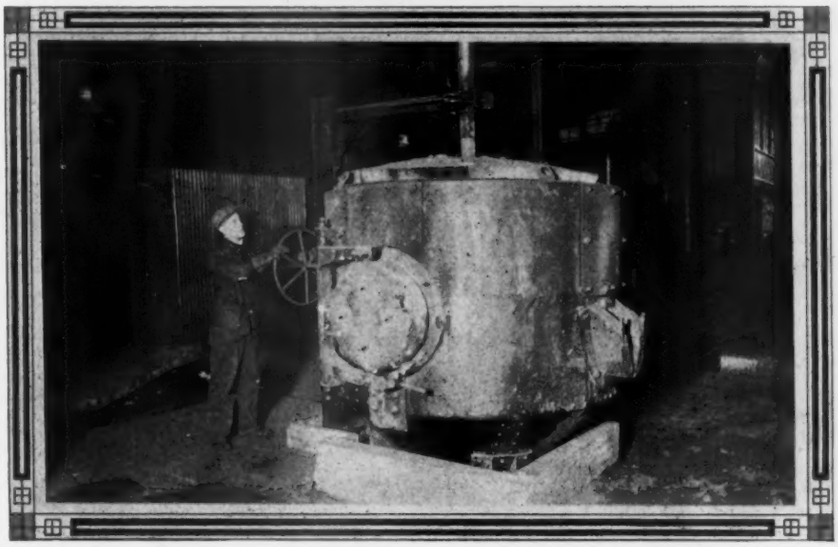


FIG. 7—THE SNYDER ELECTRIC FURNACE HAS A CAPACITY FOR PRODUCING 3,000 POUNDS PER HEAT

FIG. 8—A WELL-ARRANGED BATTERY OF HACK SAWS FOR CUTTING-OFF GATES, RISERS AND SPRUES AND FOR SLITTING CASTINGS

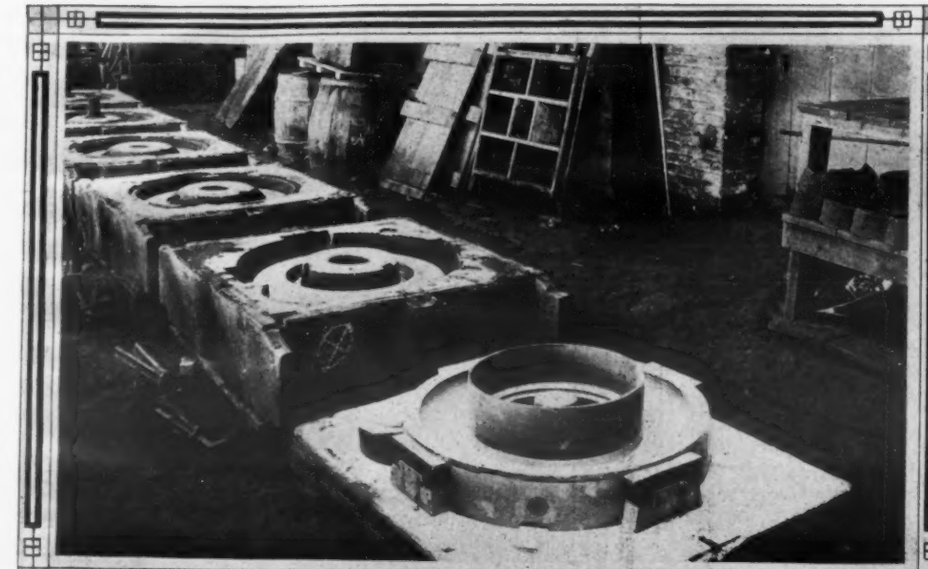


FIG. 9—PATTERN ON A FOLLOW-BOARD AND DRAG HALVES OF MOLDS FOR MOTOR TRUCK WHEELS

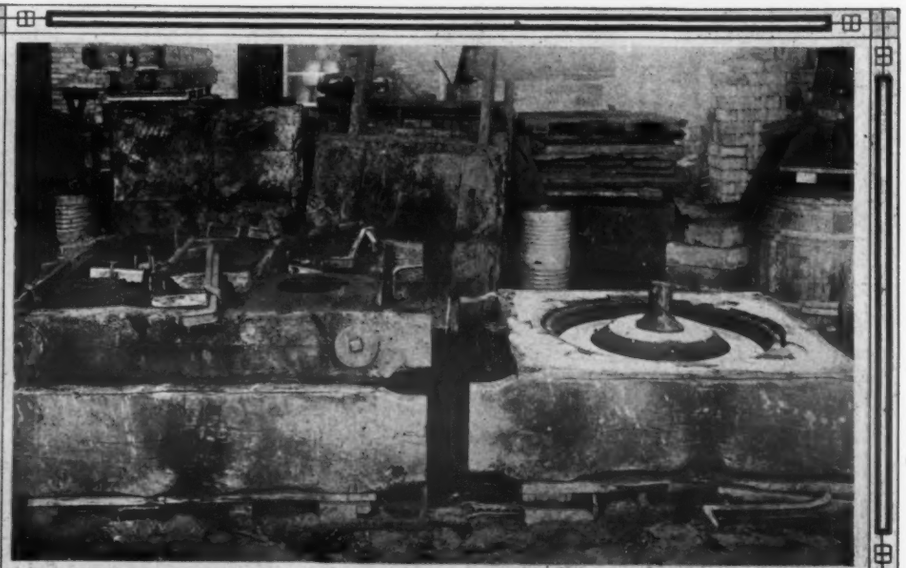


FIG. 10—DRAG HALF OF MOTOR TRUCK WHEEL MOLD AND MOLD FINISHED READY FOR CLAMPING

FIG. 11—GRID FOR CONVEYING CASTINGS FROM THE POURING FLOOR TO THE CLEANING DEPARTMENT

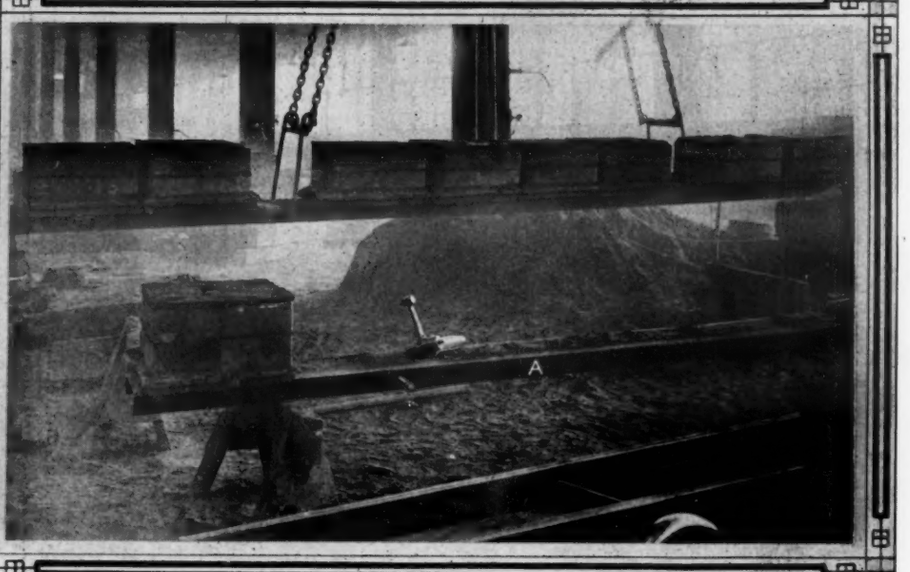


FIG. 12—ONE OF THE STEEL CHANNELS ON WHICH SNAP FLASK MOLDS ARE DELIVERED TO THE POURING FLOOR

pressor rooms and an emergency hospital also is provided.

As illustrated in the ground plan, Fig. 15, the concrete raw material bins parallel the foundry a distance of 190 feet. These are partitioned-off in size according to the material to be stored, the largest being used for sand and have a capacity of 1,000 tons. This is sufficient for the entire winter's stock and insures a constant supply in good condition. In the 17 individual bins constituting this series are stored ferro-manganese, ferro-silicon, sand blast sand, limestone, fluorspar, fire clay, charcoal, silica flour, core sand, ganister grit, coke, etc. A siding from the belt line tracks parallels the bins and through openings on a level with the cars, the raw material is unloaded. To facilitate the making of the monthly inventory of raw materials on hand, the bins are lined off every 12 inches from floor to ceiling, and by ascertaining the dimensions of the material in each bin, the volume or amount on hand can be figured easily. The pig iron and scrap storage occupies the yard space between the concrete bins and the end of the foundry. Gates are provided in the tops of the fence which are opened when unloading pig iron and scrap from cars. A gravity carrier also will be installed to facilitate unloading. Each car of pig iron is piled separately in the yard and its number and analysis are recorded in the office.

The general arrangement of the cleaning room, which is 75 x 153 feet, is illustrated in Fig. 15, and a view of this department from the shipping end toward the foundry is shown in Fig. 2 and Fig. 3 is a view from the opposite end looking toward the shipping floor. The building, which is provided with a sprinkler system, is of steel and brick construction, divided into three bays, the middle bay being served by a three-ton Pawling & Harnischfeger overhead traveling crane. It will be noted that the building is well lighted and ventilated and the floor is laid with creosoted wood block furnished by the Ayer & Lord Tie Co., Chicago. It is the intention, also, to lay a similar floor in the core shop. The orderly condition of the cleaning room, which in most casting plants usually is in a chaotic condition, is particularly striking, and the scientific arrangement of the equipment, has resulted in a greatly increased output and a large reduction in the cleaning cost. It will be noted that the grinding stands parallel the middle bay, with half of these machines in one of the side bays. The chippers' and inspectors' benches are adjacent to the shipping floor and the tumbling mills are on the opposite side of the middle bay.

After being shaken-out in the foundry, the castings are loaded on a car on rails leading into the sand blast room, Fig. 6, this track extending out into the cleaning room. From the sand blast the small castings are taken to a sprue cutter for the removal of the gates and sprues after which they are inspected, and if found defective are delivered to the welders. To facilitate this operation and to prevent the cracking of the castings, they are heated in an open fire before welding. After welding, the castings are delivered to the grinders for smoothing-up the welds and grinding other rough spots. This sequence of operations insures the movement of the castings in practically a straight line from the time they enter the cleaning room until they are shipped. The sand blast room, with the dust arrester, shown in Fig. 6, was installed by the W. W. Sly Mfg. Co., Cleveland, while the sand blast machine was furnished by the Pangborn Corporation, Hagerstown, Md. For the handling of large castings, the sand blast chamber is provided with an I-beam trolley which encircles one end of the room. The welding outfits are both of the gas and electric types.

The castings are ground on ten double grinding stands, each individually motor-driven and provided with exhaust hoods. It will be noted from Fig. 5 that the main exhaust pipe is laid underneath the floor, all overhead piping thereby being eliminated. The compressed air lines into the cleaning room also are underneath

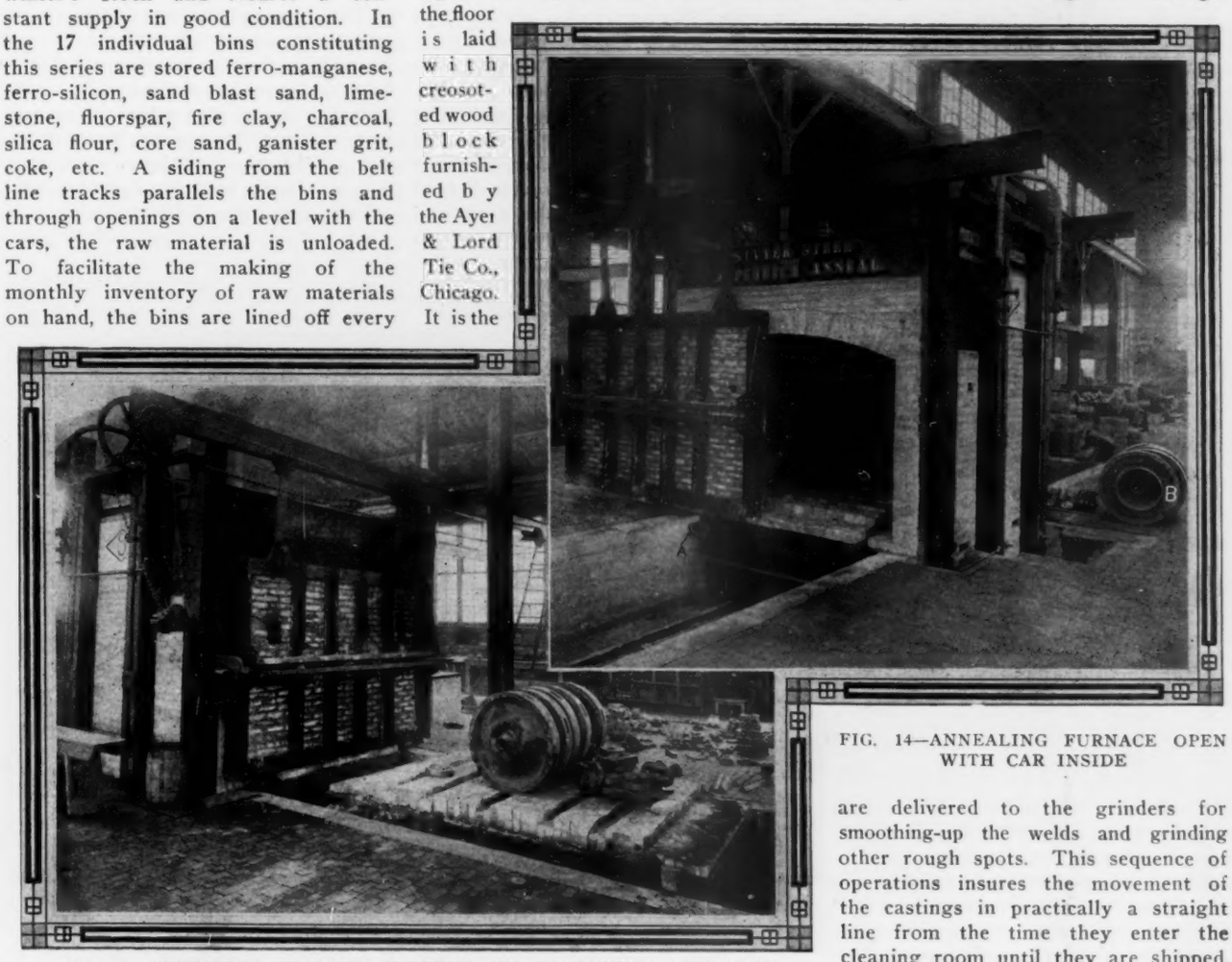


FIG. 13—ANNEALING FURNACE, SHOWING CAR CONTAINING ANNEALED CASTINGS

FIG. 14—ANNEALING FURNACE OPEN WITH CAR INSIDE

the floor, which greatly improves the general appearance of the department. The chippers' and inspectors' benches are unique in design and are substantially constructed of steel angles, bars and plates. As illustrated in Fig. 4, the tables are divided in the center, the chippers operating on one side and the inspectors on the other. The inspectors' side of the table is shown in this view. The steel center partition with the swinging doors is provided for the purpose of preventing chips from hitting the inspector, and after chipping, the castings are pushed through the hinged doors onto the inspector's table for final examination before shipment. The pipe connecting with the air line underneath the floor, which delivers compressed air to the pneumatic tools used by the chippers, passes up between the benches and has branches for each table. The chippers' tables are drilled at various points for the insertion of plugs to serve as rests for the castings. The four tumbling mills are driven by individual motors and are provided with an overhead exhaust.

Annealing Furnace

The annealing furnace, shown in Figs. 13 and 14, is of a distinctive type, designed and built by the Sivyer Steel Casting Co., and is of sufficient capacity to anneal the entire output of the plant. The furnace is oil-fired, the inside floor dimensions being 8 x 9 feet and it is 11 feet high on the burner side and slopes to 8 feet 9 inches on the opposite side. The track on which the two annealing cars operate is 40 feet long and the gage is 3 feet 6 inches. The track is depressed, thereby bringing the top of the car, which forms the floor of the furnace, on a level with the cleaning room floor. The cars are coupled together and when one is withdrawn from the furnace with its liad of annealed castings the other is pulled into the furnace with a load of castings to be annealed. The cars are hauled into and out of the furnace by the cleaning room crane, a wire cable operating on a sheave, to which the crane hook is attached, being employed for moving the cars.

A view of the furnace with one door partly open and a car inside, is shown in Fig. 14. The door is made of fire brick with a structural steel framework and is suspended from and is operated on an I-beam. The two trolleys which support the door are attached to it by a parallelogram linkwork and it is moved back and forth by a hand-operated chain belt as illustrated in Fig. 13. The two oil burners enter the furnace at one side as shown in Fig. 14, an individual air system being provided, the blower and motor being located on the roof. The temperature of the furnace is recorded by a pyrometer furnished by the Hoskins Mfg. Co., Detroit. The furnace is built of fire brick and is substantially supported by structural steel members.

The cars are of heavy steel construction and are so thoroughly insulated that no heat can be detected underneath them when the furnace is at its highest temperature. To thoroughly seal the oven a curved, V-shaped lip is cast on either side of the car, extending its entire length, as shown at *A*, Fig. 14, and steel flanges on both sides of the oven overhang into these lips. The openngs between the lips and the flanges are filled with sand, thereby effecting an air-tight seal. When closed, the door is locked in position as shown in Fig. 13.

Annealing Temperature

The furnace has an annealing capacity of about 20 tons daily and many experiments were conducted to ascertain the proper annealing temperature for steel castings. .The time required for the anneal is about six hours, the castings being heated to a temperature of 1,650 degrees Fahr., where they are held for about an hour. After they have cooled below the critical temperature of 1,100 to 1,200 degrees Fahr., it has been ascertained that they can be safely removed from the furnace. A car of annealed castings, just removed from the furnace, is shown in Fig. 13.

A well-arranged battery of hack saws, which is part of the equipment of the cleaning room, is shown in Fig. 8. The saws are used for cutting-off heads and risers and also for slitting castings to detect imperfections. The first casting on all new work is cut apart to detect defects and many recurring old jobs are investigated in the same careful manner to insure sound castings.

A large part of the work of this foundry consists of motor truck wheels and the method of molding one type is illustrated in Figs. 9 and 10. These wheels are 36 inches in

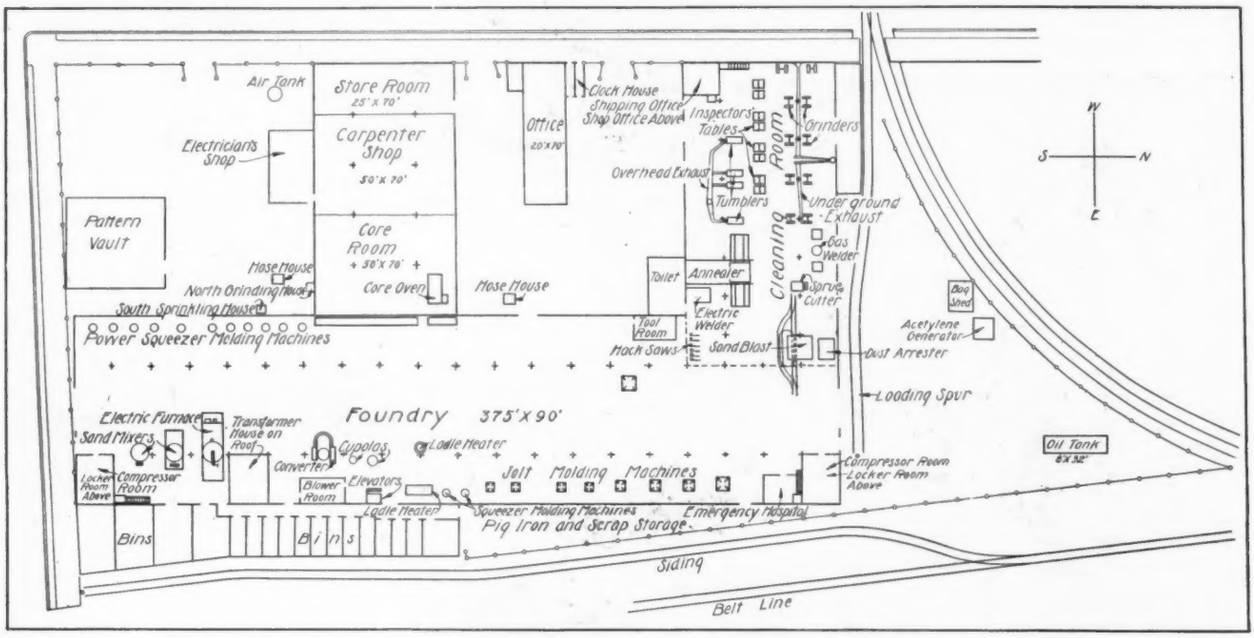


FIG. 15—GROUND PLAN OF THE PLANT OF THE SIVYER STEEL CASTING CO., MILWAUKEE

diameter and have rims 5 and 6 inches wide, respectively. In the rough they weigh 235 pounds each and 180 pounds after machining. The drive side of one of these wheels is shown at *B*, Fig. 14, and wheels showing the opposite side are on the annealing furnace car, Fig. 13. As shown by the pattern, Fig. 9, the inner side of the wheel contains a wide flange and the rim is cored throughout. The pattern on a follow-board, is illustrated in Fig. 9, as well as several drags in incompleted stages. Fig. 10 shows a finished drag with the cores in place ready to receive the cope. The circular rim core is made in four segments, the center core in three segments and in addition, there are hub and gate cores. The mold ready for clamping is shown in Fig. 10, and it will be noted that it is provided with four large risers. On Saturday, March 25, the Sivyer company received a rush order for these wheels for motor trucks for United States army service in Mexico. On the following Wednesday the first shipment of wheels was made, which were both sand-blasted and annealed, and shipments continued at the rate of 25 a day until the order was filled.

That "Safety First" is the underlying principles of all the operations of this plant is indicated by the orderly condition of all of the departments, which is the first essential in the prevention of accidents and the production of high grade work. The chief inspector also is head of the safety department and the recommendations for the installation of safety appliances are made by a safety committee consisting of one member from each department. Meetings are held every Thursday afternoon and the recommendations are reported in writing to the plant executives for their consideration. The members of this committee are constantly changing, thereby affording each employe an opportunity to serve and come in direct contact with the safety work of the plant.

To promote interest in the prevention of accidents, bulletin boards are conspicuously displayed in all departments, containing suggestions for safeguarding health and life. These bulletins are changed from time to time and the employes are urged to read them. Chippers, melters and all employes handling molten metal are forced to wear goggles and congress shoes for the molders are bought in large lots by the company, being sold to the men at cost. Safety signs also are permanently displayed in various departments. Two of these signs are shown on the chippers' benches in Fig. 4. Some of the permanent signs follow. "Fight dangerous practices, play it safe;" "Always be careful, keep your head;" "Accidents don't just happen, each one has its cause," etc. The safety work has greatly reduced the number of injuries to employes, and furthermore, it has installed a spirit of orderliness and care which has beneficially affected the operation of the entire plant.

A group insurance policy has been written on the lives of all of the employes of this company on the following basis: $1,000 for all employes in continuous service two years or more; $750 for continuous service less than two years and more than one year, and $500 for continuous service less than one year and more than six months.

Problems in Pipe Foundry Practice

By F M Warner

IN THE February issue of THE FOUNDRY, page 53, was published an interesting article entitled "Problems in Pipe Foundry Practice Discussed." The ideas and suggestions offered herewith are presented in a spirit of helpfulness, rather than criticism. Naturally each man thinks his way is the best one to follow in solving a problem, but that is not my main reason in submitting the solutions to these problems, since they are offered only to bring out a certain point.

All of these problems are solved by what I call a rule-of-thumb method, which calls for no use of the imagination. We should be able to see each problem clearly in space and to solve it as a space problem. The rule-of-thumb method is all right in some cases if the problem happens to fall in one of these classes where we have a geometrical system worked out. We all know that practical problems that come to an office are not all alike. Consequently, when a new problem comes along, we have not only missed the practice of solving each problem in space, but we are farther away from that practice than ever on account of having used rule-of-thumb methods so much. Every problem that arises should be clearly thought out in space and solved on paper on its own merits, not because it is like, or nearly like, some other problem we have worked or seen worked. If this is done, a draftsman, instead of falling in a rut, will be advancing in his ability to think out problems of all kinds correctly. He will soon be in a position where he does not have to depend upon a geometrical solution which he or someone else may have worked out, but he will be absolutely independent of all these and capable of solving more difficult problems than he ever could by any sort of rule-of-thumb method and he could do them in less time.

Drafting Room Problems

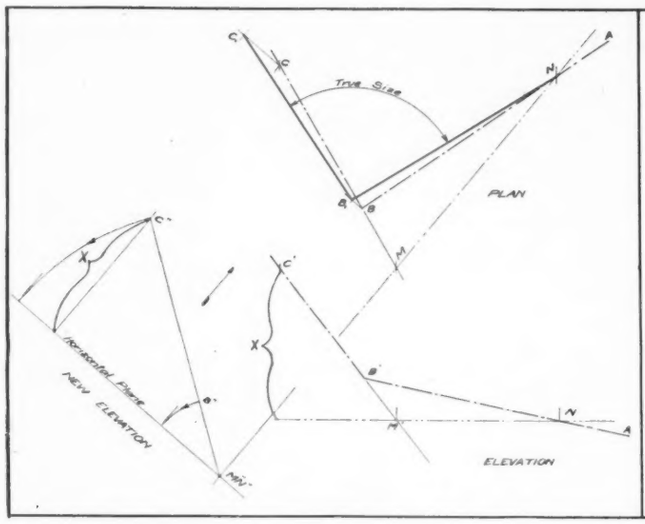
My idea is this. Why do we not solve all drafting room problems in the same way in which we take two or three views of a machine? If we have a machine to draw, we show what we can by two views. If we need any more views we draw them. I claim that we should do that same thing with any space problem, whether the problem deals with an engine or with the center lines of drain pipes. Any problem that I have ever seen can be solved by simply taking another elevation or two, the same as with a machine. This is not only better practice, but is quicker and is more certain of results.

Accompanying this discussion are my methods for solving problems Nos. 1, 2 and 3. While I do not claim they are the only way, they are simple, sure and quick methods which will work under any conditions. Furthermore, if a different case came to me for solution, the practice in seeing these problems in space would make any other problem that much easier.

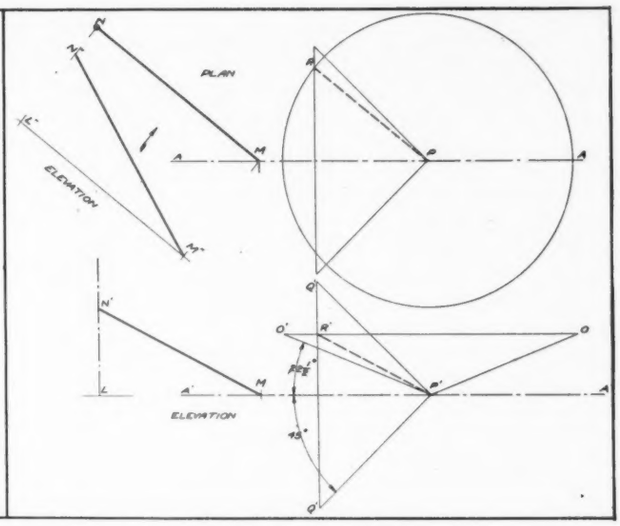
To bring out a point which I wish to make plain, I have taken a more general case than is considered in problem No. 1 discussed in the February issue of THE FOUNDRY.

Let *AB* and *BC* be the plan and *A'B'* and *B'C'* be the elevation of the center lines of any two drains. To find the true angle of the branch.

Let *M'N'* be any level line touching *AB* and *BC* in space. Project the points *M* and *N* to the plan view. Take a new elevation looking along the level line *MN* which appears as a point. Locate points *C* and *B* in this view by placing them on a line of sight parallel to *MN* and by giving them the same elevation above *MN* that they had in the front elevation. Revolve the plane of these lines about *MN* as an axis until the plane is level. In the plan view,



SOLUTION OF PROBLEM NO. 1



SOLUTION OF PROBLEM NO. 2

C appeared to move out at right angles to the axis to C, B to B and N, being on the axis, did not move; NBC is the true size of the angle of the branch. This will solve any possible case.

Let AA and $A'A'$ be respectively the plan and elevation of the center line of a main drain and N the plan of a vertical line in which a trap is to be set. We are to use a stock, 135-degree branch and a stock syphon trap with a tail at 112½ degrees and the problem in No. 2 is to find the place to insert the branch and the height at which to set the trap.

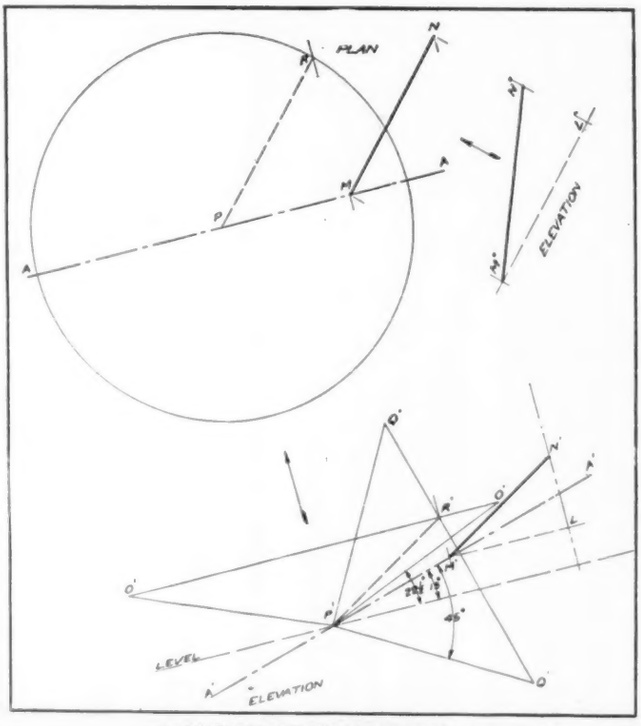
Any line that lies on the surface of the cone $P'Q'Q'$, shown in the elevation, must make an angle of 45 degrees with the line $A'A'$.

Any line that lies on the surface of the cone $P'Q'Q'$, shown in the elevation must make an angle of 22½ degrees with a horizontal plane. Draw these two cones with all the elements of both cones the same length (any length) and with the vertices at the same point P on the line $A'A'$; P can be taken at any point along the pipe. The line $P'R'$, which lies on both cones makes 45 degrees with $A'A'$ and has the proper slope of 22½ degrees. Project R to the plan view and draw MN in the plan parellel to PR and $M'N'$ in the elevation parallel to $P'R'$. This gives the point of intersection M, of the two drains and the elevation of the trap. A new elevation in the direction of the arrow gives the true length of the branch drain and the slope should check out to be 22½ degrees. This is easily solved for any angle of branch, any angle of tail of the trap and for any location of the trap.

Let AA and $A'A'$ be respectively the plan and elevation of the center line of a main drain and N the plan of the vertical line in which is to be the trap. A stock, 135-degree branch is to be used and also a stock syphon trap with a tail at 112½ degrees. To find the place to insert the branch and the height at which to set the trap, is the problem in No. 3.

It will be noted that the ordinary front elevation is not used because the true 15-degree fall of the main drain would not appear in that view. Therefore a new elevation is used looking at right angles to AA in the plan and which will show the true length and true slope of the main drain. From here the solution is exactly the same as for problem No. 2. The line $P'R'$, which lies on both cones (shown in the elevation) makes 45 degrees with the main drain and has a slope of 22½ degrees. All three angles are seen in their true size in the same view, the elevation, and also we see there the height at which to set the trap. The true length of the branch is found by taking a new elevation at right angles to MN as in problem No. 2.

This is easily solved for any angle of the branch, for any angle of the tail of the syphon trap, and for any location or any grade of the main drain.



SOLUTION OF PROBLEM NO. 3

Problems Nos. 2 and 3, instead of being solved by two entirely different rule-of-thumb methods, are solved by the very same line of thinking in space. I would like to suggest that the draftsman, who made the drawings in the article published in February, work in the third angle instead of the first angle. First angle drawings are used somewhat in England, but not at all in this country and are considered obsolete here. The difference between the two is this: In third angle drawing a view is always placed on the side where you stand to look at an object. In first angle drawing you take a view of an object from one side, then you walk around the object and place the view on the opposite side from where you stood to view the object. I hope that I have succeeded in making plain my point.

Electric Furnace Installations in Foundries

Complete List of Units of Various Types Operated in the Casting Plants of the United States and Canada

IN NUMBER of installations, if not in individual capacity, electric furnaces operated in foundries in the United States and Canada greatly exceed the installations made by the steel mills for the production of material for rolling purposes. In small units, the electric furnace is well adapted to steel casting manufacture, particularly in the production of small castings requiring a hot, fluid metal. On the other hand, the electric furnace of fairly large size also can be used to advantage in steel foundry work and enters into direct competition with the open-hearth for this purpose.

Some headway has been made in the use of the electric furnace for melting brass and bronze, but there is only one installation of this kind in operation in this country at the present time. According to figures recently compiled 36 electric furnace installations have been made in foundries in the United States and Canada, not including one large experimental and laboratory electric furnace plant under erection at Clearing, Ill. The electric furnaces installed in these casting shops total 46, of which 39 are engaged in the production of steel for casting purposes, five for making malleable iron and two for brass and bronze.

Electric Furnaces for Malleable

The National Malleable Casting Co. is the only malleable producer that is successfully utilizing the electric furnace, having installed three 6-ton Heroult furnaces in its plant at Chicago and two 6-ton Heroult furnaces at Sharon, Pa. The Chicago Bearing Metal Co., Chicago, has installed two Snyder electric furnaces for melting brass, while the Snyder Electric Furnace Co., Chicago, is building a plant at Clearing, Ill., which will contain four furnaces for experimental and laboratory purposes.

One of the most interesting recent installations of electric furnaces was made at the plant of the Sivyer Steel Casting Co., Milwaukee, where the excess shop scrap in the form of converter steel, which heretofore has been sold, is to be utilized. It is well-known that sulphur in converter steel practice must not exceed certain prescribed limits, but by repeated melting of all of the shop scrap these limits would be exceeded and since only a comparatively small amount of such scrap can be utilized in the cupola mixtures, the excess heretofore has been sold. It is this steel scrap which is to be melted in the electric furnace recently placed in operation.

Types of Furnaces Installed

Among the furnaces installed are the following types: Snyder, Heroult, Rennerfelt, Gronwall, Girod and Kjellin. In number of plant installations Wisconsin and Michigan lead with five each, although Wisconsin with its five installations has only five furnaces, as compared with New York with four installations and seven furnaces. Michigan, with five installations, has a total of seven furnaces and Illinois with three installations has six furnaces, although four additional furnaces for experimental and laboratory purposes are to be installed at Clearing, Ill., which will make a total of 10 furnaces for this state. Pennsylvania has six furnaces in four installations. Milwaukee, which ranks first in the manufacture of small steel castings, also leads the cities in number of installations with four, but Chicago, which has only three plants, has a total of six furnaces, one of these being devoted to the production of cast steel, two to brass and three to malleable iron. In Milwaukee, however, four furnaces are in operation for the manufacture of cast steel. The electric furnace installations in the foundries of the United States and Canada follow:

California

Llewellyn Iron Works, Los Angeles; one Heroult furnace, capacity, 3 tons per heat.

Monarch Foundry Co., Stockton; one Heroult furnace, capacity, one ton per heat.

Connecticut

Connecticut Electric Steel Co., Inc., New Britain; one Heroult furnace, capacity, two tons per heat.

Illinois

Chicago Bearing Metal Co., Chicago; two Snyder furnaces for melting brass mixtures.

Electric Steel Co., Chicago; one Snyder electric furnace with a capacity of 12 tons in 24 hours.

National Malleable Casting Co., Chicago; three Heroult furnaces of six tons capacity per heat.

Snyder Electric Furnace Co., Chicago, is building a plant at Clearing, Ill., which will be equipped with four electric furnaces for experimental and laboratory purposes.

Indiana

American Steel Foundries, Indiana Harbor, Ind.; one Heroult furnace with a capacity of six tons per heat.

Electric Steel Co. of Indiana, Indianapolis; one Heroult furnace with a capacity of three tons per heat.

Massachusetts

General Electric Co., Pittsfield; one Kjellin furnace with a capacity of 400 pounds per heat.

Michigan

Buchanan Electric Steel Co., Buchanan; two Heroult furnaces, one with a capacity of three tons and one with a capacity of two tons per heat.

John A. Crowley Co., Detroit; one Gronwall furnace with a capacity of five tons per heat.

S. Fair & Son, Saginaw; one Snyder furnace with a capacity of six tons in 24 hours.

Michigan Steel Casting Co., Detroit; two Heroult furnaces, one with a capacity of six tons and one with a capacity of three tons per heat.

Monroe Steel Casting Co., Monroe; one Snyder electric furnace.

New York

General Electric Co., Schenectady; three Heroult furnaces, one with a capacity of five tons and two with a capacity of two tons per heat.

Niagara Electric Steel Corporation, North Tonawanda; one Snyder electric furnace with a capacity of six tons in 24 hours.

Otis Elevator Co., Buffalo; two Snyder electric furnaces with a capacity of 60 tons in 24 hours.

W. P. Taylor Co., Buffalo; one Heroult furnace with a capacity of two tons per heat.

Ohio

Buckeye Steel Casting Co., Columbus; one Heroult furnace with a capacity of six tons per heat.

Crucible Steel Casting Co., Cleveland; one Heroult furnace with a capacity of one ton per heat.

Dayton Steel Casting Co., Dayton; one Snyder electric furnace with a capacity of 12 tons in 24 hours.

Oregon

Electric Steel Foundry Co., Portland; one Girod furnace.

Pennsylvania

Lebanon Steel Foundry Co., Lebanon; two Heroult furnaces, one with a capacity of one ton and one with a capacity of two tons per heat.

National Malleable Casting Co., Sharon; two Heroult furnaces with a capacity of six tons per heat.

Treadwell Engineering Co., Easton; one Heroult furnace with a capacity of two tons per heat.

Union Spring & Mfg. Co., New Kensington; one Heroult furnace with a capacity of six tons per heat.

Texas

American Well & Prospecting Co., Corsicana; one Snyder furnace.

Utah

American Foundry & Machine Co., Salt Lake City; one Rennerfelt furnace for castings and ingots; three tons capacity per heat.

Washington

Skagit Steel & Iron Works, Sedro-Woolley; one Rennerfelt furnace with a capacity of 1,500 pounds per heat.

Washington Iron Works, Seattle; one Girod furnace of three tons capacity per heat.

WISCONSIN

Crucible Steel Casting Co., Milwaukee; one Snyder furnace with a capacity of 12 tons in 24 hours.

Gerlinger Steel Casting Co., Milwaukee; one Snyder furnace with a capacity of six tons in 24 hours.

Pelton Steel Co., Milwaukee; one Snyder furnace.

Racine Steel Castings Co., Racine, owned by the Belle City Malleable Iron Co.; one Heroult furnace of three tons capacity per heat.

Sivyer Steel Casting Co., Milwaukee; one Snyder electric furnace with a capacity of 12 tons in 24 hours.

CANADA

Thomas Davidson Mfg. Co., Montreal; one Snyder electric furnace with a capacity of 12 tons in 24 hours.

The Rennerfelt Electric Arc Furnace

By C H Vom Baur

THE Stassano furnace was the forerunner of the Rennerfelt, the former having started with a radiating arc, playing almost horizontally over the bath, whereas the latter furnace forces the naturally large arc flame violently down on the charge and away from the roof by employing a different method of electrode arrangement. Polyphase current of any frequency and voltage is used. The advantage of a solid bottom has long been recognized, and the extensive installation (33 in operation and 20 building) of this furnace in less than four years, is largely due to this feature in conjunction with the first-mentioned characteristic. The Rennerfelt furnace idea is illustrated diagrammatically in Fig. 1.

Furnace Capacity

The almost universally used 3-phase current is shown entering the transformers and is changed by means of a Scott connection to a 2-phase 3-wire system. The middle or combined conductor carries about 40 per cent more current in the vertical than in either of the side electrodes, and this forces the entire large radiating arc, by the resolution of forces and electro-magnetic action, down on the bath. This form of arc has hitherto been unknown in electric furnaces. The horizontal electrodes are about 15 inches (38 cm.) above the bath or slag, in some of the larger size furnaces, and the operating distance from tip to tip of the horizontal electrodes is usually from 18 to 22 inches (45 to 55 cm), or more. These dimensions give an idea of the size of the flame, which, striking the bath, mushrooms to the sides and ends of the furnace. The heat reaching the roof, consequently, is indirect, thus favoring low roof-maintenance costs. These low roof-refractory costs have often proven themselves in practice; for instance, when melting cold steel scrap and making tool steel quality, heats taking 5 to 6 hours in a low-power furnace, at about 150 kilowatts per ton capacity of the furnace, the roof has lasted 192 heats with a 9-inch brick. With faster melting and the 12-inch brick, more heats could be expected per roof.

The furnace is built in different sizes. The first 30 furnaces were three tons and under in capacity. Since then, a four-ton furnace has been placed in operation and a second is expected to follow shortly. Eight-ton furnaces are building, while 12-ton and larger furnaces are being contemplated.

On account of the peculiar characteristic of the Rennerfelt arc, it is very steady with hand regulation, and the furnace operation is electrically simplified to a marked degree, by avoiding all automatic electrode regulation, although motors with push-button control are contemplated. As only 4 to 6 pounds of Acheson graphite are burned away per ton of cold steel scrap or pig melted and treated, it is evident that the electrode regulation with such a steady arc, made betwen three points of stability, that is, the tips of three electrodes, is a minimum, and this has been proved in practice. The electrodes oftentimes do not have to be adjusted for half an hour, and still the power consumption is about as steady during these periods as with an induction furnace. Light metal scrap or turnings can be heaped in the furnace with the electrodes touching the charge, and yet before many minutes the free-burning arc between the electrode tips has established itself.

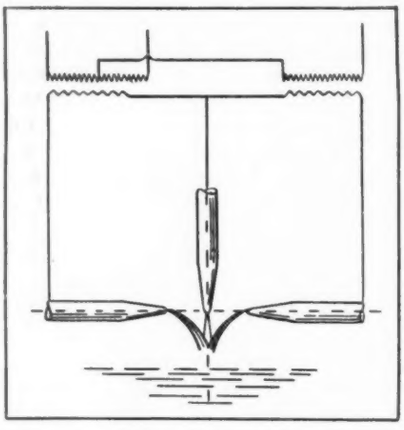


FIG. 1 — ELECTRODES AND CONNECTIONS OF THE RENNERFELT ELECTRIC FURNACE

With the exception of three or four furnaces, all are operated with basic bottoms. Only a few operate with acid bottoms, and these are in tool steel works where the highest class of raw material is available at reasonable prices. The bottoms of these furnaces last as long as similar solid bottoms of open-hearth furnaces. The sides burn away a little faster and wear away also, due to the slag action, and the roof wears faster than the sides.

Wear of Electrodes

The wear of the electrodes seems to depend on three factors: First, the density of the current; second, the circular area and length exposed inside the furnace; and third, the amount of air leaking into the furnace. The latter cause seems to have the most deleterious effect and hence doors are fewer now than formerly. Up to the three-ton size there is only one door and that over the spout, all other furnaces have but two doors and these are much tighter. The clearance of the cooling boxes also is made less. Only ⅛-inch clearance is allowed, which is just enough room to compensate for the slight irregularity in the manufacture of what are ordinarily perfectly round electrodes.

The electrical conditions are most satisfactory, as evidenced by the opinions of central station managers. On account of the high power factor at 50 to 60 cycles, it being 90 to 97 per cent, the phase displacement is almost entirely avoided, and the phases are almost perfectly balanced.

The so-called efficiency of electric furnaces depends, as has been broadly discussed by Hering and others, on the rate at which the heat is forced into the furnace, besides upon good insulation, proper painting, etc. The main point of these is the rate at which the power is consumed.

From a paper presented before the American Electro-Chemical Society, April 29.

Three or four years ago, 200 kilowatts were considered ample for a one-ton furnace; now 350 to 375 for this size is common practice. Consequently, the melting time has decreased and the kilowatt-hours per ton are less, the cost of the steel in the ladle is less, and the output is correspondingly increased. The practical limit to this high-powering of furnaces is the power of the refractories to withstand the higher heat for sustained periods, the refractories also are subjected to greater differences of temperature between heats, especially with those furnaces where the electric current cannot be maintained while there is no charge in the furnace.

Power Consumption

With low-powered Rennerfelt furnaces the power consumption when treating various metals has been as follows:

Melting	Killowat-hours, metric ton.
Red Brass	168
Pure copper	197
White iron	290
Gray iron	325
Eighty per cent ferro-manganese	441
Steel scrap, not ready to pour	455
and killing steel scrap on an acid bottom, about	600
Eighty per cent ferro-manganese and holding, tapping and charging	741
Making 67 per cent ferro-tungsten, small scale	5,730

Furnace Characteristics Summarized

The characteristic features of the furnace may be summed up as follows:

The heat is generated by an arc, exceedingly hard strains on the power supply being absent.

On account of the steady power and on account of the large flame widely diffused, the heat is communicated to the charge quicker than with arcs of the thin-penciled type, made between the tips of the electrode and the bath.

A large flame or a series of them sweeps all over the major portion of the charge in the center of the furnace, or at regular distances along the major axis of the furnace, and is directed and violently deflected downwards.

The heat being thrown downward in this way and being a radiating arc of large volume, the roof, therefore, has a long and satisfactory life.

The furnace has only one small hole in the short-radius roof for each set of electrodes, both of these features making for strength and lower maintenance cost.

The hearth is more easily surveyed and accessible, during operation, than in arc furnaces having electrodes only 2 or 3 inches above the slag.

With larger furnaces multiple arcs are used, this method starting in with the 6-ton furnace. The heat is applied more directly, although the arc is not. There is no water-cooling below the bath, which consequently avoids danger of explosions from this source.

The voltage at the arc is from 75 to 100, depending on the furnace size, and these potentials are harmless if a shock is experienced.

The amperes per electrode in large furnaces is small, namely, 5,400 and 7,700 in a 3,600-kilowatt furnace.

The hearth bottom is burned in by the arc without the use of coke or other material.

The electric current can be kept on the furnace during tapping and charging, thus maintaining the furnace at a uniform temperature, with its consequent advantage of keeping the refractories from checking. The furnace, therefore, does not cool down and a saving of 10 to 20 minutes in time can be made on this account per heat, this being the usual charging time.

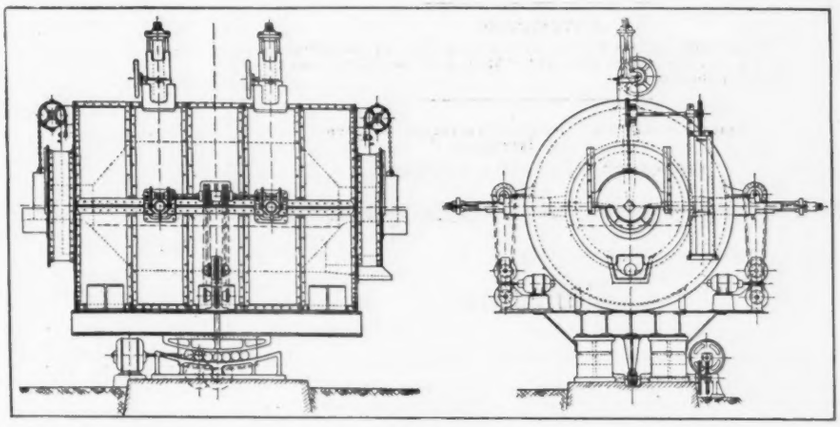


FIG. 2—FRONT ELEVATION AND CROSS-SECTION OF A 12-TON RENNERFELT ELECTRIC FURNACE

Will Increase Capacity

George Oldham & Son Co., manufacturer of pneumatic tools and appliances, Frankford, Philadelphia, Pa., recently has purchased the complete equipment for a new power plant. Also, the upper floor of this company's present building now is being utilized and a large amount of new machinery is being added. This will greatly increase the capacity of the plant, which is made necessary by the growing demands for the company's product.

The Federal Foundry Supply Co., Cleveland, has been awarded the contract for furnishing all of the navy yards of the United States government with amorphous and flake graphite for the current year.

A New Use For Gasoline Generating Sets

A new adaptation of the gasoline generating set, built by the B. F. Sturtevant Co., Hyde Park, Mass., has been made by the United States government in its use in aeronautical training camps and for field searchlights. Several of these outfits have been ordered by the United States government and one is in successful operation at the United States Signal Corps Aviation School, San Diego, Cal. These sets are intended for use in direct connection with lighting and power circuits and not through storage batteries, although they may be so arranged if desired. A sensitive governor control insures a constant voltage through wide variations of load. The unit consists of a portable electric generating set made up of a direct current electric generator, direct-connected to a gasoline engine, a switchboard and gasoline tank also being included. A special type of disc fan is mounted on an extension of the generator shaft and is arranged to blow air through a cellular type radiator. All of this apparatus is mounted upon two steel channels and the engine generator and switchboard are covered by a sheet metal housing similar to an automobile hood. The engine is of the vertical, water-cooled type, and has either four or six cylinders, according to the size of the unit. Three sizes of these sets are built, namely 5, 10 and 15 kilowatts, capable of lighting 200, 400 and 600 twenty-candle power lamps.

The Vanadium Alloys Steel Co., Pittsburgh, Pa., has issued two folders descriptive of its non-shrinkable grades of tool steel.

THE FOUNDRY

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Trade Outlook

LABOR shortage, to some extent, is curtailing foundry operations, but notwithstanding limited operating forces, the melt in gray iron, steel, malleable and brass shops is of record proportions. The scarcity of molders is not nearly so pronounced as that of common labor and higher wages and shorter hours is the universal demand. With a few exceptions, the leading foundry centers have been notably free from strikes, although the present month foreshadows trouble for many casting manufacturers. On the other hand, the demand shows no signs of diminution and deliveries are being further deferred. The unfilled tonnage on the order books of the merchant furnaces, which is the highest in the history of the pig iron industry of this country, reflects the anxiety of foundrymen regarding an adequate supply of their raw material and also, in a measure, can be considered as indicative of their tremendous volume of business for future shipment. Price no longer is a factor, prompt delivery alone being considered by many purchasers. Railroad freight embargoes which persist notably in the east, have been a harvest for the express companies, and thousands of tons of castings have been forwarded in this way. The general condition of the foundry industry is without parallel in the annals of the trade and a continuation of the present situation, if not more acute, is promised throughout the remainder of the year. New construction and additions to existing capacity are being delayed by inability to secure building materials, machinery and equipment, and the capacity, therefore, is not expanding as rapidly as otherwise might be the case. As noted elsewhere in this issue, an interesting development of the situation is the widespread installation of electric furnaces in foundries in the United States and Canada, and the demand for these melting units seems to be measured only by the ability of the builders to make deliveries. The scarcity and high prices prevailing for steel pots, in several instances has been the persuading factor in discontinuing the production of crucible steel in behalf of electric. Milwaukee, the leading center of small steel casting production, leads all other cities in number of electric furnaces, and indications favor a further expansion of this practice in that city. One of the gratifying features of the situation is the continuance of domestic demand, only a very small percentage of the casting tonnage indirectly being attributable to so-called war orders. Malleable foundries are crowded to capacity, although the melt is curtailed to some extent by the shortage of labor. Steel casting plants, particularly those devoted to light work, report a flood of new business and practically the same situation prevails in the gray iron and brass shops. While there has been a limited amount of buying of pig iron and metals for delivery into next year, this is due more to the hesitancy of the sellers than the melters. Price advances are almost of daily occurrence and their frequency makes them pass with little or no comment. Pig iron quotations are being firmly maintained as follows: No. 2, Chicago and Cleveland, $19; Buffalo, $18.50; Philadelphia, $20, and Birmingham, $15. Malleable is strong at $19.50, Chicago, and $18.50, Buffalo, while Lake Superior charcoal is $19.75 to $22.25, Chicago.

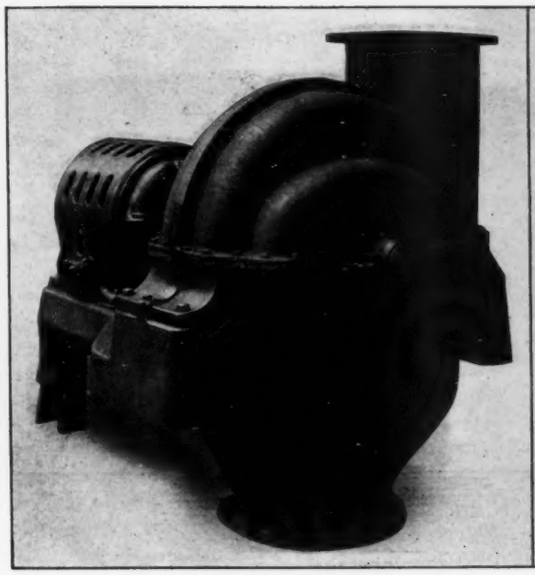


Fig. 1—Ingersoll-Rand Turbo Blower for Furnishing Blast to Cupolas

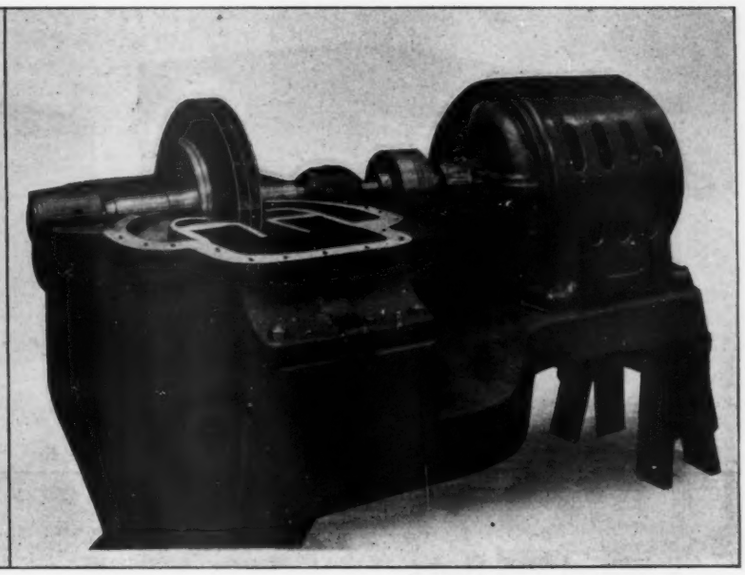


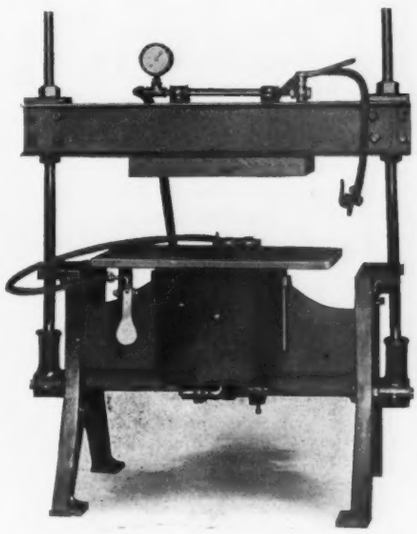
Fig. 2—Blower With Upper Casing Removed, Showing Double-Flow, Enclosed Impeller

A Turbo Blower for Cupola Operations

THE Ingersoll-Rand Co., New York City, has added to its line of turbo compressors and blowers a low pressure machine to handle volumes from 3,000 to 35,000 cubic feet per minute at from 1 to 2½ pounds. These are particularly adapted to such service as cupola blowing, atomizing oil for oil burners, supplying blast to heating and annealing furnaces of various types, blowing air for water gas generators, pneumatic conveying and ventilating. They are of the single-stage, double-flow type and are furnished either with an electric motor, steam turbine or are water wheel-driven. Electric drive generally is employed for the classes of service previously mentioned and in this type of turbo blower the high operative speed permits direct coupling to the motor.

The motor-driven turbo blower maintains a constant pressure while delivering any volume from zero to maximum demand and proportionately varying the electrical horsepower input. These blowers embody the four-bearing construction, which is a feature of all turbo machines built by the Ingersoll-Rand Co. The casing is split horizontally for ease in installation and subsequent inspection. The assembled casing is doweled and bolted to a heavy sub-case, which serves ordinarily for both blower and driving element.

The impeller is of the enclosed, double-flow type, the wheel being machined from a solid steel forging. Vanes and covers are made of pressed steel, securely riveted. All rivet heads are driven flush and the entire assembly is polished. All impellers are overspeeded in a testing machine to insure correct balance, strength and to eliminate vibration. The impellers are keyed to a heat-treated forged steel shaft. The bearings are ring-oiled and both bearings and their housings are horizontally split. The machines are of the closed intake type, the intake opening being at the bottom and the discharge at the top. It is claimed that the flow of air from this type of blower is absolutely uniform, avoiding all pulsations, which makes it especially desirable for foundry work. The absence of rubbing surfaces is emphasized and this precludes the necessity of adjustment to take up wear and minimizes the cost of maintenance. Only the bearings require lubrication, all other parts operating without friction. The turbo blower assembled and ready for installation is shown in Fig. 1, while Fig. 2 is a view of the machine with the upper casing removed, showing the double-flow, enclosed impeller.



POWER SQUEEZER DESIGNED FOR HEAVY WORK

A New Power Squeezer

The Federal Foundry Supply Co., Cleveland, has designed and is building the power squeezer shown in the accompanying illustration, which is adapted particularly for heavy work. It is provided with a 12-inch cylinder, has a 6-inch stroke and the distance between the rods is 40 inches. The machine is built in both portable and stationary types. A smaller size, with a 9-inch cylinder and a 4-inch stroke has a distance of 30 inches between the rods. It is provided with a knee vibrator and air valve.

The Iroquois Foundries, Inc., Utica, N. Y., have built a foundry for the manufacture of a special white metal. Four metal melting furnaces have been installed by the Buckeye Products Co., Cincinnati. Officers of the Iroquois company follow: Charles J. Rath, president; Charles E. Day, vice president; Harold E. Rath, secretary, and Fred Widmer, treasurer and general manager.

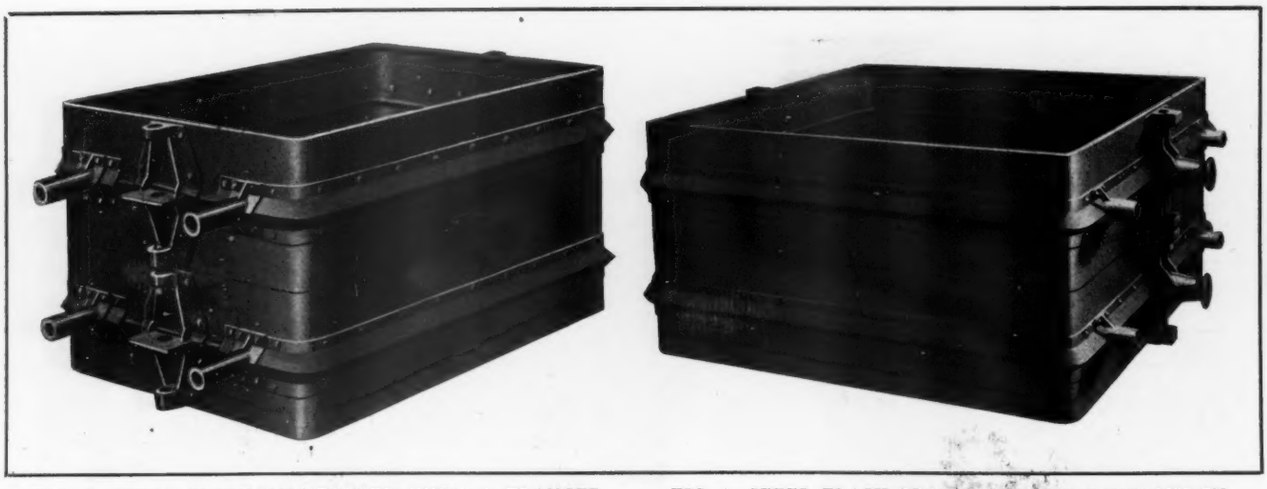


FIG. 1—STEEL FLASK REINFORCED WITH A FLANGED STEEL ANGLE

FIG. 2—STEEL FLASK PROVIDED WITH TRUNIONS IN ADDITION TO HANDLES

Reinforced Steel Flasks

The utility of steel flasks is generally recognized by foundrymen and the line of this equipment built by the Sterling Wheelbarrow Co., Milwaukee, has been extended by the addition of flasks reinforced with flanged steel angles, thereby greatly adding to the strength of the rolled channel steel sections from which the flasks are constructed. The flask, illustrated in Fig. 1, is reinforced at the sides, corners and ends with flanged steel angles and it is equipped with double lug malleable iron pinholders and handles. All sections are drilled so that they are interchangeable and any cope may be used with any drag or multiple section flasks may be made from two-part flasks. This type of flask is made in widths from 12 to 30 inches and in lengths from 18 to 60 inches. The copes, cheeks and drags are made in heights from 3 to 8 inches.

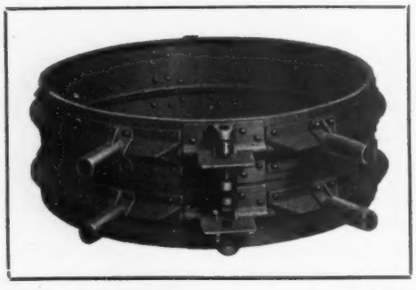


FIG. 3—CIRCULAR STEEL FLASK REINFORCED WITH FLANGED ANGLE WHICH STRADDLES CENTRAL REINFORCING RIB

Another type of flask similar to the one shown in Fig. 1, but which is equipped with malleable iron combination double lug pinholders and trunnions, in addition to handles, is shown in Fig. 2. This combination makes it possible for the foundryman to handle his flasks, roll-over the copes and to make his lifts by means of a chain, air or electric hoist. The double-lug pinholders also make this flask desirable in multiple molding or multiple section work. This type is made in widths from 12 to 24 inches and in lengths from 24 to 60 inches.

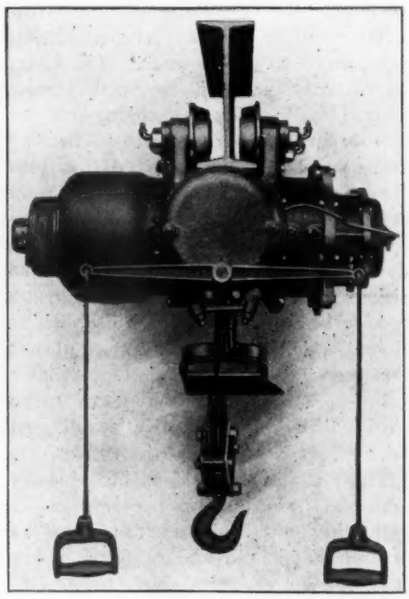
Fig. 3 shows a circular flask equipped with the flanged angle reinforcement which straddles the central reinforcing rib and extends from pinholder to pinholder. This flask is well adapted for circular molds of fairly large or medium size. It is built in diameters ranging from 18 to 42 inches and in heights of cope and drag from 3 to 8 inches. All sections are equipped with double lug malleable iron pinholders and are drilled absolutely interchangeable. These double lug pinholders and the interchangeable drilling enable a foundryman to make multiple section flasks out of a number of two-part flasks or to engage in multiple molding. All sections are equipped with malleable iron handles, as shown in the illustration.

A New Electric Hoist

A new electric hoist recently developed by the Shepard Electric Crane & Hoist Co., Montour Falls, N. Y., is shown in the accompanying illustration. While it retains practically all of the constructive details of the company's earlier models, some changes have been made in gear construction.

The hoist frame consists of two cylindrical castings, flanged and joined to each other at the center of the hoist by turned, through bolts. The outer ends are closed by bonnets secured to the frame by bolts. One of these bonnets enclose the motor while the other covers the receptacle containing the gearing and brakes. All moving parts are thus protected.

The motor is of the standard, series-wound, slow-speed crane type. When the hoist motor is running without load its speed is about two and one-half times its full load speed. The controllers are either of the foundry control or single speed control type. The foundry control type gives from 13 to 17 running speeds while the single speed control is used for starting, stopping and reversing the motor only.



A NEW ELECTRIC HOIST

The hoist gearing consists of a double train of spur gears having either two or three speed reductions. All gears drive at two points diametrically opposite, thus dividing the work among double the number of gear teeth that would be in contact

by the usual arrangement. Since the gears are in a double train, breakage at two points simultaneously would be necessary before the load would fall.

A mechanical brake is used, which automatically holds the load when the motor is at rest, and prevents excessive speed in lowering. An electric brake applied directly to the motor shaft, is provided for all hoists having foundry control. All single speed hoists are provided with a manually-operated motor brake.

The hoist is built upon the unit system, all parts being readily accessible. The motor, controller, gearing and mechanical brake, electric brake, limit switch, and winding mechanism are each independent of the other and each may be removed without disturbing any other unit.

Personal

P. J. Krentz, foundry superintendent of the Buffalo Foundry & Machine Co., Buffalo, has been appointed works manager.

Alexander C. Brown, vice president of the Brown Hoisting Machinery Co., Cleveland, has been appointed general manager to succeed Richard B. Sheridan, resigned.

P. J. Cornelissen, formerly operating the Boston Metal Co., Boston, which was destroyed by fire, is now in charge of the foundry of Merriman Bros., Boston.

A. E. Wright has been promoted to the position of secretary and treasurer of the Dominion Steel Foundries, Hamilton, Ont., and Fred W. Sherman has been named purchasing agent.

Walter L. Ronstrom, formerly affiliated with the Hubbard Steel Co., East Chicago, Ind., is now connected with the Marshall Foundry Co., and will have charge of its new plant at Black Lick, Pa.

W. J. Reardon, formerly superintendent of the foundry of the Westinghouse Electric & Mfg. Co., Pittsburgh, Pa., has been appointed superintendent of the brass foundry operated by the Rome Mfg. Co., Rome, N. Y.

Nelson E. Frissell has taken over the sand business of the Gardner General Foundry Co., Gardner, Mass., and will supply tested core sand to the foundry trade. The business will be carried on under the firm name of the Frissell Engineering & Contracting Co. It will make periodical analyses of sand used by foundries to keep heaps and core sand mixtures uniform.

I. L. Houghton, who for the past 10 years has been affiliated with the United States Malleable Iron Co., Toledo, O., as assistant treasurer and production manager, has resigned. During the 25 years Mr. Houghton has been interested in the foundry business he was connected in various capacities with the National Malleable Castings Co., Toledo; the Michigan Malleable Iron Co., Detroit, and the Grand Rapids Malleable Iron Co., Grand Rapids. Mr. Houghton still retains the position of secretary and treasurer of the Superior Iron & Mfg. Co., although not active in the management of the affairs of this company.

Arthur Falkenau, vice president of the Hooper-Falkenau Engineering Co., New York City, has been appointed acting consulting engineer of the Canadian Car & Foundry Agency, which is supervising the production of munitions for Russia in 80 or more plants in the United States and Canada. Mr. Falkenau has had an extended experience in munitions manufacture, having made shrapnel for the United States government during the Spanish-American war and he has built special machines to his own and United States government designs for several United States arsenals.

Rennerfelt Electric Furnace Installations

Hamilton & Hansell, Whitehall building, New York City, have made the following recent sales of Rennerfelt electric arc furnaces in the United States:

Skagit Steel & Iron Works, Sedro-Woolley, Wash.; one ¾-ton for castings.

American Foundry & Machine Co., Salt Lake City, Utah; one three-ton for castings and ingots.

Charleston Steel Co., Charleston, W. Va.; two eight-ton for ingots.

In addition to the foregoing, the following orders for electric furnaces have been placed abroad:

Aktiebolaget Svenska Järnvägsverkstäderna, Linköping, Sweden; one 1¼-tons for castings.

Stchetinine, Petrograd, Russia; two ¾-ton for castings.

Larsbo-Norn, Aktiebolaget, Vikmanshyttan, Sweden; one 1¼-tons for tool steel.

Noes Järnverk, Tvedestrand, Norway; one 1/3-ton for tool steel.

Hults Bruk, Sweden; one ¾-ton for tool steel.

William Beardmore & Co., Ltd., Forge, Scotland; one three-ton for steel castings and special steels.

F. H. Lloyd & Co., Ltd., James Bridge Steel Works, near Wednesbury, Eng., one 1/3-ton for ferro-manganese.

The foregoing recent orders make a total of 54 Rennerfelt furnaces contracted for or in operation, of which 21 are in course of construction.

Loam Mixture

Question:—Kindly give us a suitable mixture for loam for molding large marine engine cylinders, etc. What are the proportions of clay, sand and other ingredients?

Answer:—As you are located on one of the Great Lakes, the following mixture is convenient for you to obtain: Mix one part of chopped straw with two parts of lake sand and add four parts of good molding sand. Wet with medium thick clay wash.

NEW TRADE PUBLICATIONS

AIR COMPRESSORS.—A 32-page bulletin printed in two colors, recently has been issued by the Ingersoll-Rand Co., New York City, which illustrates and describes its line of duplex, corliss, steam-driven air compressors. These machines are made in different types with cross-compound steam and two-stage compressing cylinders with overhead inter-cooler, compressors with cross-compound steam and two-stage compressing cylinders and compressors with cross-compound steam and duplex single stage air cylinders. Details of the compressors are illustrated and described and tables of dimensions are included.

AUTOMATIC FURNACES FOR ANNEALING, HARDENING, TEMPERING, ETC.—A line of automatic furnaces has been built by the W. S. Rockwell Co., 50 Church street, New York City, which is described in a well-illustrated bulletin containing 16 pages. The product to be heat-treated is charged into these furnaces automatically, being discharged directly into the quenching tanks from which they are conveyed to the tempering furnaces for the final heat-treatment. Continuous die annealing and hardening furnaces also are shown, as well as furnaces of other types, including automatic rotary annealing and automatic, rotary hardening.

TURBO BLOWERS.—The Ingersoll-Rand Co., New York City, has issued a 12-page bulletin illustrating and describing its turbo blowers adapted to such work as foundry cupola blowing, atomizing oil for oil burners, supplying blast to various kinds of heating and annealing furnaces, pneumatic conveying systems, etc. The bulletin is well illustrated and in addition to half-tone views of the blower, it also is shown in section and a list of sizes and dimensions also is included. Another bulletin issued by this company is devoted to its line of air compressors, while the third describes the Leyner-Ingersoll drill.

WHAT THE FOUNDRIES ARE DOING

Activities of the Iron, Steel and Brass Shops

The Miami Foundry Co., Hamilton, O., will move its plant to Miamisburg, O.

The Hoosier Castings Co., Connersville, Ind., has increased its capital stock from $35,000 to $100,000.

The Campbell, Wyant & Cannon Foundry Co., Muskegon Heights, Mich., has increased its capital stock from $150,000 to $400,000.

The Central Foundry Co., Marshalltown, Ia., has been reorganized and is now known as the American Machine Products Co.

The Liberty Foundry Co., St. Louis, has increased its capital stock from $25,000 to $75,000.

The Berlin Machine Works, Beloit, Wis., has changed its name to the P. B. Yates Machine Co. The company manufactures woodworking machinery.

The Kainer Mfg. Co., 761 West Mather street, Chicago, manufacturer of automobile parts and pumps, has added a brass foundry.

The E. H. Myers Mfg. Co., Myerstown, Pa., has been incorporated with a capital of $15,000 to engage in the manufacture of machinery and tools and to operate a foundry and machine shop.

The Freeport Foundry Co., Freeport, O., has been incorporated with $10,000 capital by L. W. Gilcher, B. W. Rowland, C. L. Harding, R. W. Gilcher and H. B. Gilcher.

The Bay State Foundry Co., Westfield, Mass., has been incorporated with a capital stock of $25,000 by William C. Waldron, Theodore R. Brien and Harry B. Putnam.

The Hugh Merrie Brass Co., Cincinnati, has been incorporated with $25,000 capital by Carl T. Foley, H. E. Zerfey, Eleanor S. Patterson, F. M. Schwein and Rose L. Brink.

The Canadian Welding Works, Montreal, Que., Can., has been incorporated with a capital stock of $10,000 to engage in the manufacture of iron and steel castings.

The Federal Brass Foundry Co., 36 Broad street, Boston, has been incorporated with $10,000 capital by Ralph C. Barnstead, Frederick M. Callahan and Sidney G. Barnstead.

The Universal Foundry Co., Oshkosh, Wis., has been incorporated with a capital of $10,000 by L. J. Monahan, J. D. Termaat and A. C. Ziebell.

The Dayton Malleable Iron Co., Dayton, O., has taken over the Ironton Malleable Co., Ironton, O. The plant will be equipped for the production of small automobile castings and about 400 molders will be employed.

The Insurance Foundry Co., Covington, Ky., has been incorporated with a capital stock of $10,000 to engage in the foundry business. The incorporators are Harman H., George B. and Robert H. Uckotter.

Barr Registers, Trenton, N. J., has been incorporated with a capital stock of $300,000 to manufacture metal goods, castings, etc. The incorporators are Wilson Barr, William H. Matthews and Stephen F. Washington.

The Huntington Steel Foundry Co., Huntington, Ind., has been incorporated with $225,000 capital to engage in the manufacture of iron and steel castings. The directors are Edwin B. Ayres, H. E. Rosebrough, J. W. Caswell, F. E. Wickenhiser and A. L. White.

The Foundry & Machine Co., Montreal, Que., has been incorporated with $200,000 capital to engage in the foundry business and to manufacture machinery, tools, munitions, motors, etc. John L. Tolland, Joseph U. Emard, John A. Sullivan and G. A. Normandin are the incorporators.

The Iron Works Co., Owen Sound, Ont., has been incorporated with a capital of $96,000 to operate an iron foundry, boiler and machine shop and to build engines, boilers, machinery, tools, etc. The incorporators are Francis M. Kilbourn, John McEwen and Samuel A. McDougall.

New Construction

The Keystone Iron Works, 959 North Main street, Los Angeles, Cal., will erect a foundry.

The Robinson Supply Co., Robinson, Ill., will erect a machine shop and foundry.

The Buffalo Foundry & Machine Co., Buffalo, is building an addition to its plant.

The Plume & Atwood Mfg. Co. will build a foundry, 78 x 175 feet, at Thomaston, Conn.

The Bahr Bros. Mfg. Co., Marion, Ind., is erecting a 54 x 200-foot gray iron foundry.

C. L. Dorer & Co., Bellaire, O., are building a 30 x 50-foot addition to their foundry.

Joseph Gertler, 676 Drolet street, Montreal, Que., will erect an addition to his foundry.

G. P. Gonthier, St. George, Que., will build a foundry at a cost of $4,000.

The Enterprise Machine Works, Santa Cruz, Cal., is building a foundry.

The Western Iron Foundry Co., Wichita, Kas., will erect a reinforced concrete building at a cost of $4,000.

The Huron Foundry Implement Co., Bad Axe, Mich., will erect a foundry, 50 x 100 feet, and a manufacturing building.

The American Shipbuilding Co., Cleveland, will erect a 120 x 200-foot foundry and machine shop at its Lorain, O., plant.

George W. Kimball, Springfield, Mass., will build a four-story, 64 x 91-foot foundry which will be leased by the P. P. Emory Co.

The Birmingham Iron Foundry, Derby, Conn., will build a foundry, 62 x 208 feet, with an ell, 40 x 140 feet.

The United States Radiator Corporation, Chicago, will erect additions to its plant at Edwardsville, Ill.

The Valley Iron Works, Williamsport, Pa., is erecting a 40 x 100-foot addition to its foundry.

The American Steel Foundries, Chicago, is building an addition, 65 x 150 feet, to its foundry, at Alliance, O.

The Beaver Motor Car Co., Gresham, Ore., is erecting a foundry for the manufacture of malleable castings.

The Detroit Valve & Fittings Co., Wyandotte, Mich., will erect a 50 x 72-foot addition to its annealing room.

The Kelly & Jones Co., Pittsburgh, will build a converter steel foundry at its works at Greensburg, Pa.

A contract has been awarded for the erection of a foundry by the W. J. Murphy Co., Amesbury, Mass.

The Smith & Windham Co., South Windham, Mass., will build a foundry, 69 x 85 feet, at a cost of approximately $25,000.

The Coosa Pipe & Foundry Co., Gadsden, Ala., contemplates making extensions to its plant.

The Jenkins Mfg. Co., Bloomfield, N. J., will erect an addition, 12 x 30 feet, to its foundry.

The Shoop Bronze Co., Tarentum, Pa., recently incorporated with a capital stock of $25,000 is building a foundry, 45 x 100 feet.

The Pollard Mfg. Co., Niagara Falls, Ont., Can., is building a foundry at a cost of $10,000.

The Electric Steel Foundry, Portland, Ore., will rebuild its plant recently damaged by fire.

Bids are being received by the Franklin Foundry, Franklin, Pa., for the erection of a foundry addition, 40 x 140 feet.

Plans are being prepared for a foundry addition, 96 x 120 feet, to be erected for the National Foundry Co., Erie, Pa.

Smith & Caffrey, Syracuse, N. Y., contemplate building a foundry at a cost of approximately $25,000.

The Canadian Iron Foundry Co., Montreal, Que., contemplates erecting an addition to its plant at Three Rivers, Que.

The St. Louis Frog & Switch Co., St. Louis, is erecting a foundry at a cost of approximately $30,000, for the manufacture of manganase steel castings.

A contract has been awarded for the erection of a two-story, 40 x 100-foot addition to the plant of the Farrel Foundry & Machine Co., Ansonia, Conn.

The W. A. Jones Foundry & Machine Co., Chicago, will increase its capacity by the erection of an addition which will contain approximately 100,000 square feet.

The Claus Automatic Gas Cock Co., 2601 Vliet street, Milwaukee, will build a foundry and machine shop, 90 x 150 feet, at Booth street and Keefe avenue.

The New England Brass Co., Taunton, Mass., recently incorporated with $125,000 capital, will erect a rolling mill, 60 x 125 feet, and a casting shop, 50 x 50 feet.

The city of Camden, N. J., will build a high school, which will include a machine shop, foundry, forge and boiler shops and a power plant, at a cost of $500,000.

Another story, 40 x 42 feet, will be added to the two-story fire-proof pattern shop and vault of the Wisconsin Foundry Co., 1138 Thirty-second street, Milwaukee.

The Atlas Foundry & Machine Co., Tacoma, Wash., will erect a three-story concrete building, 32 x 100 feet, at a cost of approximately $10,000.

The Denver Iron Works & Foundry Co., Denver, Colo., will erect a 75 x 75-foot foundry at a cost of $10,000 and a two-story, 28 x 110-foot machine shop at a cost of $10,000.